# COMPRESSED AIR MAGAZINE

EVERYTHING PNEUMATIC.

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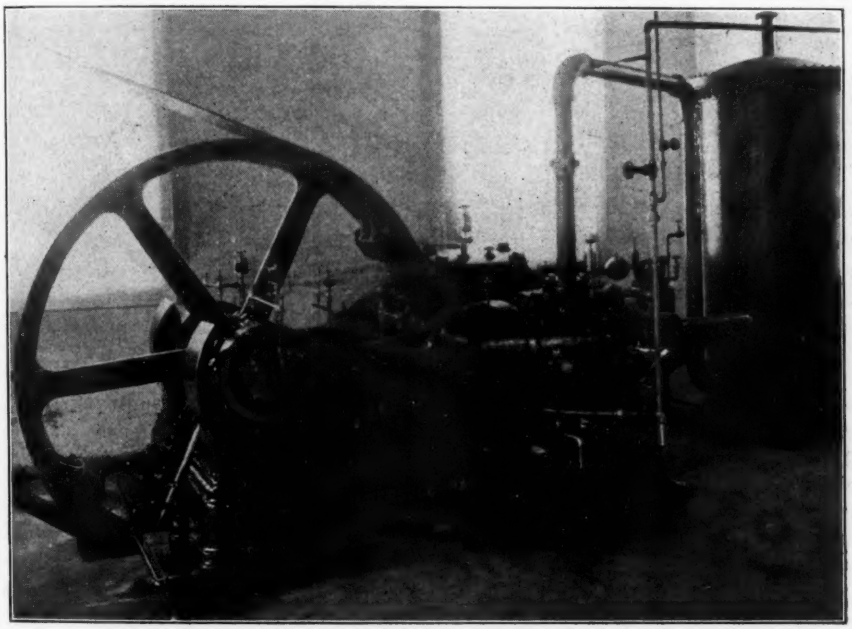
## COMPRESSED AIR IN TEXTILE MILLS

BY ALBERT W. THOMPSON, MECH. SUPT. AMOSKEAG MFG. CO.

Early in 1902 the writer began his experience with compressed air with an outfit consisting of a second hand air brake pump, one three inch chipping hammer and a small piston air drill. This outfit was the "thin end of a wedge" which opened the way for a plant consisting today—only seven years later—of air compressors aggregating in capacity about 3600 cubic feet per minute, permanent distribution mains throughout a territory over a mile in length and nearly half a mile in width and pneumatic service for tools and apparatus of varieties almost too numerous to mention.



400 CUBIC FEET AIR COMPRESSOR AT AMOSKEAG MANUFACTURING CO.'S PLANT.

The Amoskeag Manufacturing Company, Manchester, N. H., is the largest textile manufacturing plant in the world, and, besides its textile mills, it operates its own machine shop, foundry and boiler shop, also constructing all

its own buildings. Its mechanical department naturally provides an extensive field for the use of such pneumatic tools as chipping and riveting hammers, drills, stone tools, hoists, etc., which are too well known to require description here. The writer will therefore endeavor to confine himself to the description of such applications and methods as are peculiarly adapted to mill construction and textile mill service, or which differ from those already widely used.

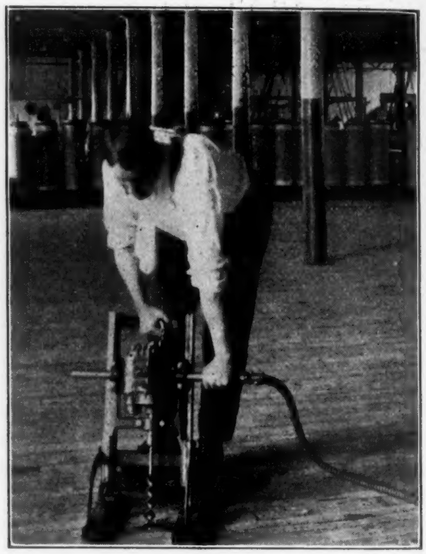
In mill construction pneumatic service is invaluable, so much so, indeed, that the writer ventures the assertion that the economy secured by the use of pneumatic tools in the construction of a 25,000 spindle mill would pay the entire cost of purchase and installation for a compressed air plant of sufficient capacity to be subsequently used for cleaning and humidifying for the entire mill.

Where rock drills are required in foundation work, air is more convenient than steam, and stone tools of the "plug drill" type are much more efficient than hand work for foundation stone, etc. If old brick are at hand they may be cheaply and satisfactorily cleaned with a small pneumatic chipping hammer, and the cleaned brick are, of course perfectly suitable for wall filling or foundations.

WOOD BORING TOOLS.

The pneumatic wood boring tools can be used to great advantage in mill construction. In the construction of the Coolidge mill now building at Manchester, a man armed with a wood boring machine fits the timbers for anchors and dogs, and easily performs work which would require at least two men with hand tools. Boring tools of the same kind are later used for hanging the shafting, which is carried in hangers, each of which is supported by two three-quarter inch lag bolts. The holes for these lags are bored with a five-eighths inch auger and the lag bolts are then screwed home with the same machine by means of a "blind nut" which fits a socket on the spindle of the boring machine. A gang of seven men will in this manner put up from eighty to one hundred hangers in nine hours, which is at least double the work that the same number of men could perform in the same time with hand augers and wrenches.

The looms in a modern weave room are always driven through the floor, which calls for a large number of belt holes, all of which are generally roughed out with hand augers. For this class of work a pneumatic boring tool may be mounted on ways which are hinged to a flat base. The hinge is adjusted and set at the desired angle, and by standing on the base the auger may be fed and withdrawn very conveniently. The hand machines formerly used at the Amoskeag required two men, one at each crank. With the pneumatic tool two men are still required, both standing on the base of the machine, and each holds one of the projecting handles of the machine. By this means the machine is easily controlled and readily



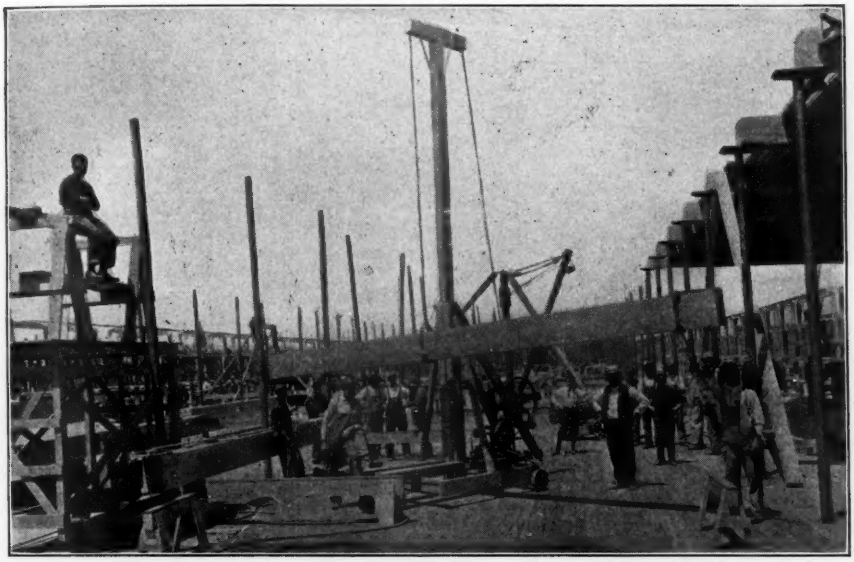
moved, and the two men can now rough out three times as many belt holes as by the old method.

PORTABLE DERRICK.

To set in place the columns and timbers of the mill a portable derrick mounted on trucks is generally provided with a hand hoist operated by six men at the cranks. In building the Coolidge mill a derrick of this type has been equipped with an "Imperial" pneumatic motor with most gratifying results. With the hand machine a gang of ten men could set about five timbers an hour, but

with the pneumatic hoist as many as twenty have been set in an hour, and a rate of twelve or fifteen per hour can easily be maintained, even when the work is somewhat intermittent. This apparatus has also been found convenient for other service, such as hoisting bundles of plank from the floor last completed to the floor above in process of construction, the plank being thus delivered exactly at the point where they are to be used.

The rapidly increasing use of cement concrete has evolved concrete mixers of many sizes and types which are in almost universal use for construction work, but for small areas of concrete flooring or machine foundations the concrete is generally mixed by hand on account of the difficulties involved in installing and driving a mixer. In addition to a large mixer, the Amoskeag Manufacturing Co. makes use of a small mixer of the "Cube" type, mounted on a truck and driven by a pneumatic motor, and the outfit is so small and compact that it can be easily moved about by two men and will pass through a door of ordinary size. It is, consequently, instantly available for all concrete work, however small, and is in almost daily use. As mechanically mixed concrete is far superior to hand mixed, and as the labor is reduced one-half, the apparatus pays for itself in a few months.



I. R. CO. IMPERIAL MOTORS OPERATING PORTABLE DERRICK AT NEW COOLIDGE MILL OF AMOSKEAG MANUFACTURING CO.

The methods above described pertain particularly to construction work, but the same tools play an equally important part in the repair and alteration work which is daily necessary in any large mill. Every superintendent and master mechanic knows the value of time in mill repairs, for often the production of a large part of the plant is stopped while a breakdown is being repaired or an important alteration made. Often, too, the location of the work is such that limited space permits only a few hands and tools to be brought to bear upon the work. It is in just such cases that the pneumatic tools are unsurpassed. The ability to bring power to any desired point by coupling up a few lengths of hose at once alters the complexion of a task which would seem almost hopeless where the old-fashioned ratchet drills and hand-chisels were the only tools available.

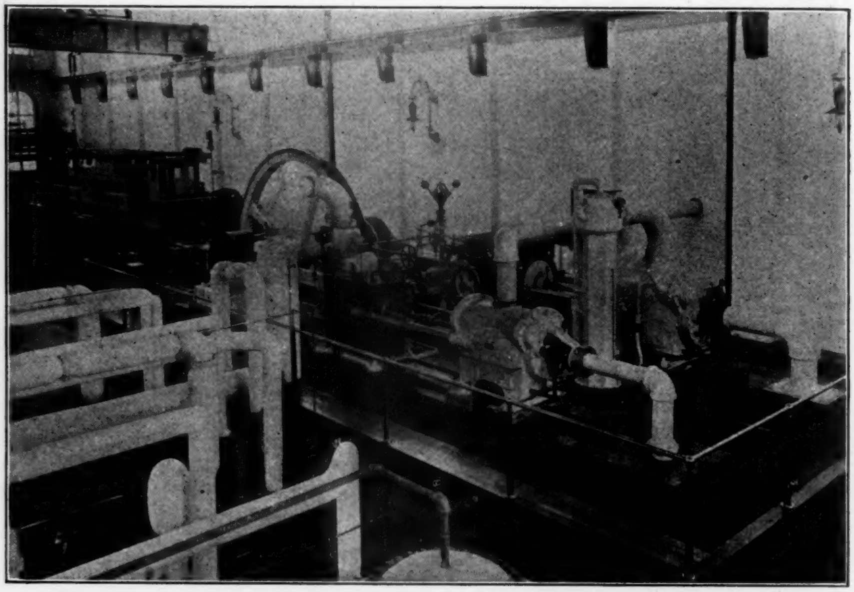
The wood boring tools are, perhaps, more readily adapted to daily use than any others. They are of great value to electricians for boring through floors or partitions when running wires, etc. They are in constant use in the carpenter shop, both for boring and for driving heavy lag and wood screws, and

it is now difficult to imagine how they could be dispensed with.

BORING LOGS.

In bleacheries and dye houses heavy maple logs are used for squeeze rolls, and the holes for the roll shafts must be bored straight and true. For this purpose the auger shaft is back-geared to a powerful pneumatic driller, both being attached to a special carriage on an old lathe bed. The log is carried on horses at the end of the bed, and the auger is fed through by hand. To drive a four inch "pod auger" through a ten foot log used to be a day's task for two men, the heart-breaking part of the task being due to the necessity for the frequent pulling out of the auger to clear the hole of chips. With the modern apparatus four ten foot logs are easily bored by one man, who requires no help except in the handling of the logs themselves to and from the machine.

All of the above uses of compressed air are for the mechanical force rather than for the manufacturing departments themselves; but we now come to the other ways in which compressed air is applied directly to the needs of manufacturing departments: namely, cleaning and humidifying.



2,500 CUBIC FEET I. R. AIR COMPRESSOR AT AMOSKEAG MANUFACTURNIG CO.'S PLANT.

CLEANING MACHINES.

For cleaning service typical cases show that the saving in labor and increase in production will pay from thirty to fifty per cent. per annum on the investment in the necessary plant. To cite a few examples:—tentering machines, stock dryers and other machines of this type, requiring ordinarily from one to two hours per week for cleaning, may be more thoroughly cleaned in fifteen or twenty minutes by the use of air nozzles than is possible by hand. Nappers, requiring half an hour's stoppage per day for hand cleaning, may be cleaned in from five to ten minutes per day by compressed air. Ring spinning, usually requiring from an hour to an hour and a half per week stoppage for cleaning, can be cleaned with compressed air with a stoppage of from twenty to thirty minutes per week—about two per cent. increase in production. In a room containing 50,000 ring spindles on No. 26's yarn, the number of hands engaged in cleaning and sweeping was reduced from fourteen to nine. In this

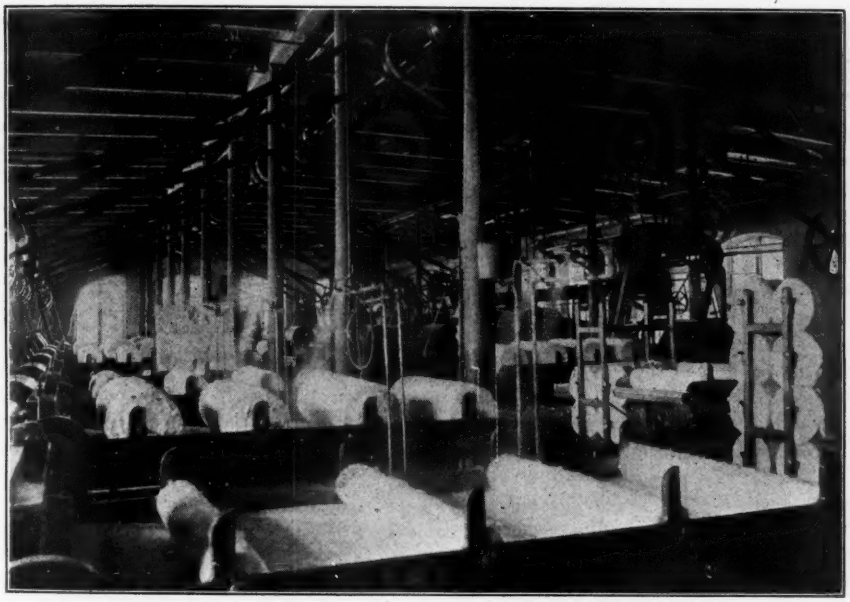
case alone the combined saving in cost of labor and value of increased production amounted to $1,700 per annum.

Pulleys, shafting and ceilings are also cleaned by air supplied through a light brass tube in a hollow wooden pole. Overhead cleaning must necessarily be done outside of regular working hours, or else the nearby frames must be stopped and afterwards dusted to prevent the lint brought down from overhead from getting into the work. Less stoppage, however, is necessary than when the overhead cleaning is done with brooms and brushes, as the work can be done in much less time and much more thoroughly.

Many manufacturers fear injury to the product from lint spun in while cleaning the frames, but as a matter of fact, the lint dislodged by the nozzle is so heavy that it settles at once to the floor if the operator uses ordinary care in keeping the point of the cleaning nozzle properly depressed. Of the many manufacturers who have tried air for this purpose, I have known none to abandon it.

POWER COST OF THE AIR.

It may be of interest to state here that the nozzle used for this type of service has a small stop valve controlled by the thumb of the operator, and an extension of about fifteen inches of quarter-inch pipe reduced to a very small opening at the tip. This nozzle consumes from twelve to fifteen cubic feet of air per minute, which corresponds to less than two horsepower, and in the spinning room above mentioned, one nozzle is in practically constant use, and for about a quarter of the time three are in use. I draw particular attention to this as there is a prevalent misconception of the amount of power consumed in the use of compressed air. As the machinery of the above mentioned room requires over seven hundred horsepower, it is clear that the power required for cleaning, considered as a percentage of the whole, is negligible; and even when viewed as an actual expense at the annual cost per horsepower it seems equally unworthy of serious consideration.



MOISTENING BLEACHED AND COLORED COTTON LAPS ON FINISHER PICKERS.
Turbo Head Above Second Lap from End of Lattice.

A weaver will clean a loom in less than two minutes with a nozzle more thoroughly than in twenty minutes by hand, and this cleaning can be applied two or three times a week if desired, with resulting improvement in the product and no appreciable loss in produc-

tion. Whenever the warp runs out the nozzle may be brought into play and all parts of the loom are then subjected to a still more thorough cleaning. It is also a fact that rooms cleaned by air will be found much freer from conditions inviting the starting and the spreading of fires—a statement which any insurance inspector will confirm without hesitation.

I have frequently been asked why no exhaust systems are used to take care of the lint dislodged by the air nozzle. This might, perhaps, be accomplished by providing a hopper under each machine, into which the dust could be swept, connected with permanent sheet metal exhaust pipes leading to fans and dust collectors, but so many objections to such a system, such as the multiplicity of pipes which would be required, and the necessity for their frequent cleaning, are at once apparent, that it may safely be condemned as impracticable. A portable dust collector or portable exhaust pipes, on the other hand, would seem equally undesirable, as it would be extremely difficult to move any such apparatus about in the narrow alleys between the machines.

Electric power has become a characteristic feature of all new textile plants of any considerable size and most progressive mills are replacing many of their older mechanical transmission system with either group or individual motor drives. For cleaning electrical machinery when exposed to the dust and the lint inseparable from textile mills, air cleaning is an essential rather than a convenience, and so widely is it used for this purpose that its mention here is perhaps superfluous.

### HUMIDIFICATION.

The necessity for artificial humidification is to-day so widely recognized by textile manufacturers that practically every progressive mill has a humidifying equipment of some sort. A few old plants have nothing more than old-style "vapor pots," but most modern plants have an equipment of one of two classes of humidifiers which may be termed the local distribution type and the air conditioning type.

Each of these has its advocates, but local distribution is more generally used, and to this system compressed air is well adapted. Most humidfier systems use water under pressure, and are characterized by bulky metallic casings and systems of drain pipes leading to filter tanks or sewers, all of which require more or less head room, obstruct considerable light and require frequent cleaning. Compressed air humidifiers, on the other hand, require no drainage systems, as all the water delivered is completely evaporated. The water used is supplied by gravity from small tanks at the level of the supply pipes, which are provided with safety overflows, and the danger of damage to stock and machinery from overflow and leakage is thus obviated. The pipes, being small, occupy so little room that they can be installed in very low posted rooms without inconvenience. On account of the small quantity of water handled and the absence of dirt in the air supplied, there is practically no accumulation of dirt or sediment, and the heads require little or no attention for cleaning or repairs.

Air humidifiers can, moreover, be operated successfully under conditions impossible with other types. In napping rooms, for instance, any system depending on drainage will become so quickly clogged with dirt or lint as to practically prohibit its use. An air system, however, operates as easily there as elsewhere. One cut shown herewith illustrates another useful function of air humidifiers, namely stock moistening, for which a special head is used to produce a coarser spray than that produced by the standard humidifiers. These are of great use in carding colored and bleached cotton, and the cut referred to shows a row of finisher pickers on which the back laps are moistened by humidifiers.

In closing the writer wishes to speak particularly in regard to the only objection he has ever heard raised to the use of compressed air—the cost of the power required to generate it. The prevalent idea on this subject is very erroneous, possibly from the fact that the average manufacturer has attached undue importance to the horsepower rating of the compressor at its full load. It is of course necessary to install a compressor of capacity sufficient for the "peak load," plus a reasonable margin for possible extensions, but in practice the duty is so variable that the mean load will generally be only from one-half to three-quarters of the peak-load, and the cost of power consumed is of course proportional to the mean load only. Furthermore, the compressor can usually be located in engine or wheel rooms where no extra cost of attendance is entailed, and the power

there only stands the manufacturer the fuel, water or electric expense.

Moreover, the relation between the cost of generating a few horsepowers and the cost of employing one unnecessary laborer or operative is often overlooked. *It costs on the average from ten to twenty times as much to employ one additional hand as it does to generate one extra horsepower.* Consequently, a compressed air plant costs very little to maintain when compared with the saving in labor which it effects.

After seven years experience with compressed air in mill work the writer is firmly convinced that the actual return on the investment in a compressed air plant well utilized is not less than twenty-five per cent. in a mill of any ordinary size, and in growing plants actively engaged in building and constructive work, it would often pay for itself in a year or less. Furthermore, the possession of this powerful auxiliary, always ready to cope with important tasks in emergency, constitutes an important asset whose value it is difficult to estimate, but which experience will prove to be by no means inconsiderable.

[For the half tones illustrating the above article we are indebted to the courtesy of the *Textile Manufacturer's Journal.*]

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### AIR LIFTS AT MEMPHIS

For the water supply of Memphis, Tenn., there is said to be the largest artesian well installation in the United States. The initial plant of the system consisted of wells 8 and 10 inches in diameter driven to an average depth of 500 feet, their combined flow being pumped into the city mains by three 10,000,000 gallon pumps. The limit of supply from this source was reached at about 20,000,000 gallons per day and the continued growth of the city made an increased supply necessary. In 1907 the Commission became convinced that the air lift wells were bored in the eastern part of the city, a larger one being added later, our ac- should be employed, and accordingly five new count being taken from the *Municipal Journal and Engineer,* New York.

The power plant installed comprised: Five 150 horse power fire tube boilers; five cross-compound, two-stage Laidlaw-Dunn-Gordon compressors with a capacity of 500 cu. ft. of free air per minute each; five compound American Steam Pump Co. pumps of 1,000,000 gallons per day each, and one duplex compound Worthington pump of 2,000,000 gallons per day capacity, all the compressors and pumps being run condensing.

There are six wells averaging about half a mile apart. Nos. 1 and 6 are situated on the city's property, and after the water is brought to the surface by the air lifts it flows down grade into the collecting basin, but with the other wells the water after it is brought to the surface is forced up a grade of nine feet ½ to ¾ mile into the same collecting basin. All wells are 10 inches in diameter with 50 feet of 8 inch Cook strainer, except Well No. 6, which is 13 inches in diameter with 65 feet of 12 inch strainer. Independent 4 inch air lines are run to each well, with a 2½ inch line in all wells except No. 6, in which a 3 inch air line is used. The air lines are so cross-connected in the station that any compressor can be connected to any well.

Wells Nos. 2, 3, 4 and 5 are located in the streets 1,000, 2,000, 3,000 and 4,000 feet, respectively, from the plant, are all connected to our general collecting main, and all except No. 5 have been placed in service.

The railroad being on the highest ridge, and it being necessary to locate the plant along it on account of the coal question, the tops of the wells are from 7 to 18 feet below the discharge in the collecting basin. Moving water by air through a long pipe with a slight upgrade from the well is highly inefficient, it being undesirable also to place standpipes in the streets high enough to cause the water to flow by gravity to the collecting basin, the following plan was resorted to:

A steel tank 6 feet high and 8 feet in diameter was sunk below the surface of the street over the top of each well, the well casing extending into the tank to within 18 inches of the top. A connection to the collecting main was run from the bottom of the tank with a check valve in same. This also extends up into the tank as high as the well tube. Over this was suspended a longer pipe, extending from a few inches above the bottom of the tank to within six inches of the top. This causes the water to follow a tortuous passage and gives an additional chance to liberate the air.

From the top of the tank a 4-inch pipe was run to a vault under the sidewalk, where it terminated in a specially designed valve so weighted as to allow the air to escape at about

the pressure due to the head of the discharge in the collecting basin above the top of the well.

This arrangement has proven highly satisfactory, the water reaching the collecting basin entirely free from air. A much higher efficiency was found than when the air was forced along with the water.

Tests were made with 8-inch and 10-inch discharge pipes and the 10-inch finally was used. The following table shows the best results of these tests:

| No. of Well | Diam. of Discharge | Diam. of Air Line | Submersion of Air Line | Operating Pressure | Draft of Well | Total Lift | Gals. Water Per Min. | Cu. Ft. Free Air Per Min. | Cu. Ft. Free Air Per Gal. |
|---|---|---|---|---|---|---|---|---|---|
| | *Ins.* | *Ins.* | *Ft.* | *Lbs.* | *Ft.* | *Ft.* | | | |
| 1...... | 10 | 2¼ | 65.2 | 60.0 | 18.5 | 73.9 | 974 | 336 | 0.345 |
| 2...... | 10 | 2½ | 63.2 | 57.5 | 13.9 | 77.2 | 883 | 332 | 0.376 |
| 3...... | 10 | 2½ | 63.4 | 58.5 | 15.0 | 78.1 | 603 | 347 | 0.576 |
| 4...... | 10 | 2½ | 66.1 | 57.5 | 17.3 | 68.9 | 701 | 307 | 0.437 |
| 6...... | 13 | 3 | ..... | 73.0 | 41.6 | 120.6 | 1410 | 514 | 0.364 |

At the time the test of well No. 3 was made the well casing only extended into the trap 24 inches. This has since been raised and the flow very materially increased without an increase of the air supply. The flow of well no. 6 also has been increased to 1,750 gallons per minute, but no accurate tests made as to air per gallon.

Since the operation of this new plant has been so successful it is felt that the water question has been permanently settled, as it will only be necessary to erect plants similar to this in different sections of the city whenever the present supply is inadequate to fill the demands of its rapid growth.

The quality of the water is acknowledged to be as near perfection as that of any other public water. The only objection heretofore existing was that the iron in it would stain china or porcelain vessels; but since the operation of this new air lift plant this objectionable feature has disappeared, and the water forms no discoloration whatever, but is as clear as crystal after having been drawn several days.

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A School of Mines is to be established at Illinois State University. It was asked for by a committee representing miners, operators, inspectors and manufacturers, and the General Assembly promptly voted the money. It is understood that the men will be especially trained to work in and investigate the problems of coal mining.

## A PNEUMATIC OILING SYSTEM

By George L. Fales.

Herewith are an explanation and illustration of an oiling system which is not advanced as anything new or original, except that the oil is all practically handled by compressed air, instead of by gravity feed or direct pump pressure.

Such a system has the advantage that the new oil is being drawn from barrels and does not enter the power station at all, the barrels remaining outside of the building, as shown in Fig. 1. The vacuum in the oil tank is induced by the pipe running to a Conover independent condenser. There is no oil wasted nor spilled by this method. All filters, oil tanks, pumps, etc., are below the engine-room floor, where they can all be attended to by one attendant. There are no unsightly tanks on the wall of the engine-room.

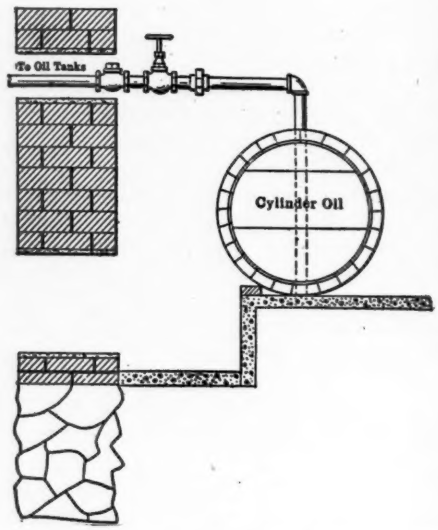


FIG. 1. BARRELS EMPTIED OUTSIDE THE BUILDING

This system consists of five tanks, Fig. 2, arranged in a row; the first four receive the waste oil drips from all the engines, which filter down through waste, and up through water in the bottom of the tank, flowing from the top of the water out into a header pipe common to the four filters, and discharging into a receptacle at the top of the tank *A*.

This tank has five ½-inch pipes, with valves attached, arranged around the circumference of the receptacle at the bottom, and discharging through these into five wire screen cylinders, closed at the bottom, and wrapped with toweling, through which all the oil filters.

These cylinders are set on a perforated plate into which space the oil drips from the cylinders, through the toweling, and then runs through the suction pipe of the oil pump, which enters the bottom of the tank, and it is then pumped to the filtered oil-storage and feed tanks by the electrically driven pump.

These tanks have an air pressure of 15 pounds applied to the top of the oil. Enough oil is kept in the system to keep both tanks two-thirds full. An overflow pipe is attached to each tank two-thirds of the distance from the bottom, and these combine and discharge together through a safety valve into the filter tank *A*, as shown.

The pump is kept running continuously and if stopped for any cause, there is enough oil in the tanks to supply the engines for some three hours, the air pressure supplying the necessary pressure to feed the oil.

When the pump is stopped, either by the circuit-breaker coming out or for any other reason, the handle of the motor-starting rheostat, in going to the off position, throws into circuit a red light which is placed in the engine room, thereby giving notice that the pump is off. The lamp continues to burn until the motor is again started.

We also have a spare pump attached to the end of the main shaft on the Conover condenser, which can be used as a spare pump.

To make up the natural loss of oil, and to keep the system at the required level, there is a pipe branching from the feed line on the new oil tank, through which new oil may be introduced into the filtered oil tanks by simply opening one valve.

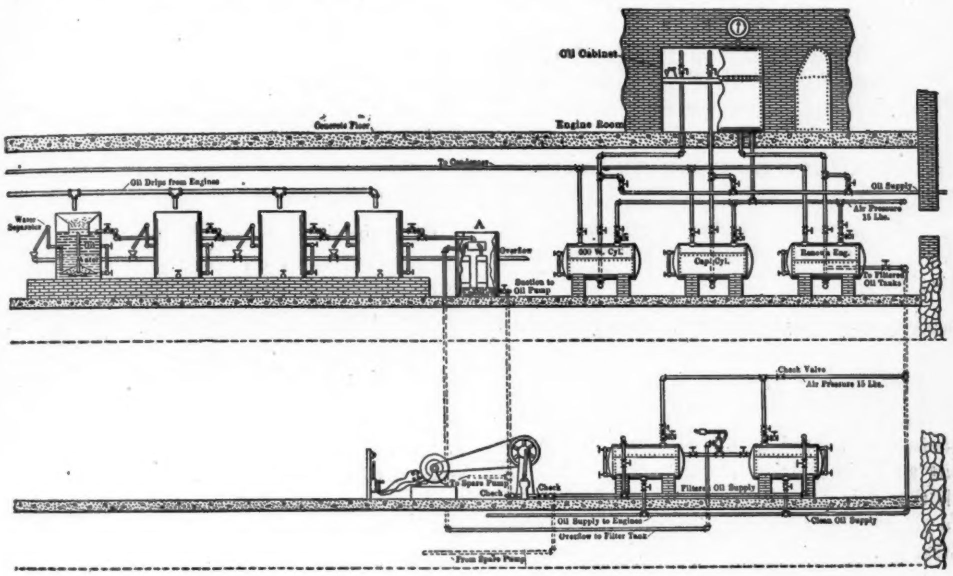


FIG. 2. VERTICAL SECTION SHOWING OILING SYSTEM.

New engine oil and two kinds of cylinder oil are drawn into three tanks arranged as shown in Fig. 2. The oil is drawn from barrels outside of the engine room through a 1¼-inch pipe. The bungs are knocked out of the barrels and the pipe put in, the union made tight and a vacuum turned on. A barrel of engine oil will flow into the tank in about five minutes; cylinder oils take more time, depending on the temperature.

When there is sufficient oil in the tanks, as shown by the gages on the ends, the vacuum is shut off and an air pressure of 15 pounds is applied to the top of the oil and kept on at all times, except when filling the tanks.

Pipes from the bottom of the tanks lead

to the oil cabinet in the engine room, and oil is measured out to the oilers from this cabinet and a record kept of it.

New engine oil is used on valve gears and in blowing-engine cylinders, and to make up loss in the filtered-oil system; all other bearings are lubricated with filtered oil which is all returned to the filters from the drip pans of the engines.

A reducing valve on the high-pressure line reduces the pressure from 120 to 15 pounds. A safety valve is attached to the low-pressure line, in case the reducing valve should stick or leak.

The installation operates very satisfactorily, and is a great saver of time, patience and oil and is reliable.—*Power and the Engineer.*

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## AIR COOLING BY REFRIGERATION

The following is a brief extract from a valuable paper by W. W. Macon before the American Society of Heating and Ventilating Engineers:

### GREATER HEAT TRANSFERS IN COOLING THAN IN HEATING AIR.

Air cooling is seldom merely a case of air warming reversed. In air warming the vapor present is heated along with the air, but it has so little weight in comparison with the air that it is neglected in heating calculations. In air cooling, however, portions of the vapor must be extracted step by step, and this process requires the absorption of the heat of vaporization necessary to reduce the vapor to water. The heat of vaporization is relatively so large that the total heat involved in cooling air may be two or three times as much as that involved in warming the same amount of air through an equal range of temperature. In air cooling, therefore, humidity is an important consideration.

Heating 43.35 pounds of saturated air at ordinary atmospheric pressure from 82 degrees to 83 degrees F. means heating 42.35 pounds of dry air and one pound of water in the form of vapor. Taking the specific heat of air at 0.238, and assuming that the specific heat of the vapor is the same as for water, or unity, the addition of heat involved is $0.238 \times 42.35 + 1 = 11.08$ B. T. U. Cooling the same weight of saturated air from 82 degrees to 81 degrees F. means a subtraction of heat of approximately $0.238 \times 42.35 + 0.026 \times 1{,}050 = 10.08 + 27.3 = 37.38$ B. T. U.; 0.026 being the weight, in a fraction of a pound, of the vapor condensed in the one-degree drop, and 1,050 being approximately the latent heat of vaporization, or the heat corresponding to that effecting the change of state from liquid to gas or vice versa. It will be noted that over twice as much heat has to be extracted for liquefying the vapor as for cooling the air itself, and this explains the important difference between air cooling and air heating, and why it is so much more expensive to cool air than to warm it. Cooling air without bringing about the saturated condition is of course no different from air warming, but an air cooling problem would always carry the conditions beyond this limitation.

### HEAT EXCHANGES IN COOLING A ROOM.

To maintain a room, as in summer, at a temperature below that outdoors means that a flow of heat will occur from the outside to the inside. The supply of heat from this source will be augmented by that given out by the people present and by the lights burned. To keep down the temperature is the work of the air supply, which must be in sufficient quantity and sufficiently below the desired room temperature to absorb the heat supply without exceeding the room temperature before escaping. The refrigerating plant must then be chosen of a capacity equal to cooling the calculated volume of air from the outside temperature to a temperature low enough to take into account the warming up which the air may get before reaching the room. Some of the limiting considerations are that the volume of air must not be so great as to cause draftiness, nor must the individual be directly exposed to air currents at low temperature.

Assume that a room is to be at 75 degrees F. when it is 90 degrees outdoors. The transmission of heat through the exposed walls for the 15 degrees range will be about 15-70, or 3-14, of what the transmission is at 70 degrees range, and it might figure that the average flow of heat through the walls is 8 B. T. U. per hour for square foot of the average exposed wall surface. If there is a large area of glass surface including skylights, through which the sun's rays can penetrate, account must also be taken of this source of heat, regarding it, for

example, as equivalent to adding two to five degrees to the outside temperature.

HEAT RADIATION OF THE HUMAN BODY.

That the animal heat from the individual is something of importance can be apprehended from the fact that the average individual will give off probably 400 heat units per hour. If the character of the walls and the relation of the actual glass surface to the total wall surface is such that the average transmission per square foot of the wall surface is about 8 B. T. U. per hour, it will be seen that each individual in the room is equivalent to an additional fifty square feet of exposed wall surface. In other words, if a relatively large number of people is to be accommodated in the room, the heat supplied from the human beings will be considerably greater than that coming in from the external sources.

Having ascertained the total amount of heat which will be supplied to the room interior under the extreme requirements for which the installation is to be designed, a measure is then had of determining the probable volume of air which should be admitted. This, of course, depends on the number of degrees through which the air is to be allowed to warm from the time it enters the room to the time it passes away. The determination of the proper number of cubic feet of air in a given time is a matter of arithmetic—the greater the range of temperature the less the volume. If a room is to be maintained at 75 degrees F. and the air by which this is to be effected is to be allowed to warm, say, ten degrees, it is obvious that the air must enter the room at a temperature approximating 65 degrees F. As there will be an unavoidable rise in the temperature of the air in its transit from the air-cooling coils and the fan to the room inlets, the actual temperature to which the air must be reduced by the refrigerating installation must be below 65 degrees F. Allowing five degrees on this account means that the air should be cooled by the refrigerating plant to about 60 degrees F.

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St. Louis is about to begin the building of a free bridge across the Mississippi, bids being asked for for the substructure work. The bridge will have main spans of 2000 feet, and the cost of the bridge and approaches is estimated at $3,200,000.

## COMPRESSED AIR LOCOMOTIVES IN GERMAN COAL MINES

The circumstance that the compressed air locomotive has become a favorite method of traction in the workings of American collieries has induced one of the large Westphalian coal mining companies, the Colner Bergwerks Verein, to make an experimental trial of the method in their Emscher pits for a district of workings where the strata are much disturbed, and consequently incapable of a very large daily output. The haulage to be done is equivalent to about 250 ton-miles in the shift of eight hours, the coal being got from four working places distant 1530, 765, 765 and 875 yards from the pit bottom respectively. The motive power, compressed air, is furnished by a two-stage compressor driven by a direct-current electro-motor of 85 horse-power, which, at 200 revolutions, supplies 159 cubic feet of free air per minute at 1500 lb. above the atmospheric pressure. The air so compressed passes through an equalizing reservoir of 35 cubic feet capacity and down the shaft to the main haulage road 299 yards below the surface by a line of 1½ in. wrought iron pipes, three other reservoirs of 35 cubic feet each being intercalated in the line at equal distances apart in the levels underground, to serve as filling places for the locomotives, which are supplied through reducing valves at 750 lb. pressure. The principal feature of the locomotive is the main air reservoir, a cylindrical vessel 10 ft. 4 in. long and 33½ in. diameter, of 57 cubic feet capacity, corresponding to 2910 ft. of free air compressed to the working pressure of 50 atmospheres. Below the main air vessel a smaller one is placed, with a reducing valve connection which brings the pressure down to 10 atmospheres, the initial admission pressure in the cylinders. The air vessels and the engine cylinders are carried by longitudinal cast iron framings mounted on a pair of coupled wheels of 19½ in. diameter, and a wheel base of 39.2 in. The total weight in running order is 5 to 6 tons. Under normal working conditions the power developed ranges from 8 horse-power to 12 horse-power, with a maximum of 24 horse-power, and the hauling capacity is forty to fifty laden coal tubs of 2180 lb. gross, or 1245 lb. net weight, each moved on an incline of 1 in 300 at 8.2 ft. per second—5.6 miles per hour. With two locomotives at work, hauling

from the four different working places, the work done in the shift corresponded to 262 ton-miles, the actual running times for the two engines being 313 min., while 642 min. were accounted for in stoppages and shunting work. The work done by the compressor during its 400 min. of running time corresponded to 374 kilowatt-hours. Under these conditions the total cost of haulage per useful ton-kilometre was 8.59 pf., equal to about 3.5 cents per ton-mile. The annual operating cost, including the outlay for power, wages, repairs, lubricating and cleaning materials, interest and sinking fund on the cost of the plant, amounts to $8,750.

During a trial extending over seven months the work has been carried on continuously without any interruption of the regular work, as even on one occasion, when the compressor was stopped for twelve hours to replace a defective valve, the engines ran to the end of the shift with the supply contained, while the main has also remained wonderfully tight; the supply reservoir, when filled at 100 atmospheres at 2 p. m. one day, showed a gauge pressure of 93 atmospheres at 5.30 a. m. on the following morning. [This shrinkage may have been largely due to the cooling of the air. Ed. C. A. M.] The general results of the trials may, therefore, be considered as satisfactory, as, although, like all compressed air machinery, the mechanical efficiency is somewhat low, and the first cost of the primary power arrangements is decidedly higher than that called for by electric locomotives, the working cost, including wear and tear and maintenance, is considerbaly lower.

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The general idea that marsh gas, so common in coal seams, accumulates and remains in cavities in the roof and higher places of a coal bed, is considerably in error. It is true that this gas is lighter than air, and that as a consequence its presence may sometimes be first noticed in such cavities and high places; however, the accumulation of marsh gas in such places will be only temporary. From the moment the gas is liberated, it is largely governed by the natural law known as "the diffusion of gases," and it immediately begins to mix with the mine atmosphere until it is distributed all through it.

## CAISSON DISEASE AND ITS PREVENTION*

BY HENRY JAPP, M. AM. SOC. C. E.

The prevention of caisson disease has not received as much attention as its cure, the general opinion being that it cannot be prevented. In forming an idea as to the possibility of its prevention, something may be learned from Nature's method of carrying out work by the aid of living organisms under air pressure.

First let us inquire whether Nature has a sufficient range of air pressure to make it necessary for a capacity to sustain variations without injury. The highest altitude on this earth is Mount Everest, 29,000 ft. above the level of the sea, and the deepest mine is Tamarack No. 3 Shaft, of the Calumet and Hecla Mines, 4,407 ft. below sea level.

The curve on Fig. 1 shows the absolute air pressure at various altitudes between these extremes. The total difference of 12½ lbs. per sq. in., or from 9¾ lbs. below atmospheric pressure at sea level (viz., 14.7 lbs.) up to 2¾ lbs. above normal, is considerable.

Mount Everest has never been ascended, but an elevation of 20,000 ft. has been reached, and men can live in comfort at an altitude of 7,000 ft., as in Mexico City, which has an air pressure of 3½ lbs. per sq. in. less than at the coast. Such a change of pressure is quite noticeable to those whose Eustachian tubes are closed, and, although the range of pressure is insufficient to produce caisson disease, yet travelers have complained of discomfort, not unlike a very mild attack, after a rapid journey by rail from Vera Cruz to Mexico City.

Eagles are known to go to great heights beyond the range of human vision, fish are capable of going to great depths in water, and beasts of prey roam from the mountain side to the valleys far below. With each descent these creature have undergone compression, and with each ascent decompression.

It will be noted that Nature has no time limit for immersion under increased pressure, and the application of pressure is a

*Proceedings of the American Society of Civil Engineers, April, 1909. Abridged.

much speedier and easier operation than that of decompression; and, while the compression is down-hill and attained with little effort, the decompression can only be attained by the continuous effort of climbing, and, in long ascents, with frequent rests, or by stages. This is surely a forecast of the stage-decompression theory.

From Nature, then, our best teacher, we learn that the time taken to enter the air-chamber may be short, the time spent in the air-chamber may be long, and the rate of coming out must be slow and accompanied by exercise.

In early compressed-air work engineers were confronted with caisson disease, and have long been striving for a remedy. Men of observation noted first that lock tenders who made frequent entry to the air-lock for short visits were much more immune from the malady than workers who stayed for a full shift, and from this argued that shortening the time in the air-chamber would be a safeguard, and, as higher pressures were used, the hours continued to be shortened until it was thought that half an hour at a maximum of 50 lbs. gage pressure was the limit of human endurance.

As the number of compressed-air workers increased, so the workmen gained in experience it was noted that workmen who suffered from the painful forms of caisson disease relieved the pain by re-entering the air-chamber.

About 30 years ago Paul Bert advanced the theory that caisson disease was caused by the nitrogen of the air being dissolved in the blood. He advocated slow decompression, suggesting 30 mins. for 2 to 3 atmospheres (15 to 30 lbs. gage pressure) and 60 mins. for 3 to 4 atmospheres. Since his time many writers and experimenters have followed in his footsteps, but it was not until Dr. Smith, of New York, suggested that a recompression chamber would act as a remedy, and E. W. Moir, M. Am. Soc. C. E., of London, without knowledge of Dr. Smith's prior suggestion, actually built a medical air-lock, or recompression chamber, in 1890, on the old Hudson Tunnel, New York, that any reliable cure for the trouble was discovered. Figure 2 shows the medical air-lock designed by Mr. Moir, of which six were used on the East River tunnels of the Pennsylvania Tunnel & Terminal R. R.

It was then found that if a man suffering from caisson disease in any of its many forms, varying from unconsciousness and paralysis to an acute pain in the limbs, was quickly recompressed and allowed to decompress slowly, in many cases a cure resulted, but not always.

This went to prove that the disease was a mechanical one, and was caused by the dissolved air in the blood and tissues becoming liberated in the body in the form of expand-

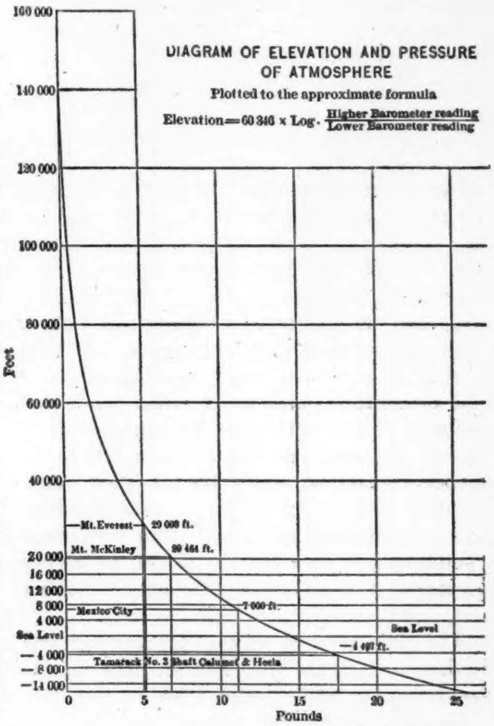


FIG. 1.

ing bubbles which tore the tissues, caused pressure on the brain, injured the spinal cord, or frothed up the blood and stopped the circulation or heart action.

Much has been done since the introduction of the medical air-lock. The percentage of carbon dioxide in the air of the working chamber has been kept within safe limits, moisture and oil have been extracted from the air before delivery to the chamber, and the workmen have been well cared for; but still caisson disease claims its victims, and engineers consider this inevitable.

The erratic manner of the disease puzzles doctors and engineers alike. Men who have

worked for months in high pressures for the regulation shift without suffering have been suddenly attacked and died; others, working only half a shift, have been paralyzed; while exceptions have worked for 12 hours at a time and have suffered only slight pains which have quickly passed away.

The writer, as Managing Engineer for S. Pearson & Son, Inc., on the East River tunnels contract for the Pennsylvania Tunnel & Terminal R. R. Co., New York, with as many as ten tunnel headings under compressed air simultaneously, has had many opportunities of studying this strange disease.

When these tunnels were commenced, in 1904, the knowledge of compressed air at the disposal of the contractor was quite extensive, and included the long experience of Alfred Noble, Past-President, Am. Soc. C. E., on caisson work in the United States, and Mr. E. W. Moir's experience on the Forth Bridge caissons, the old Hudson Tunnel, and the Blackwall caissons and tunnel.

In the light of past experience, the general conduct of the work was framed on a few established rules which when condensed amount to the following: No workman was allowed to enter the air-chamber without a physical examination by the qualified medical officer of the contractors. Sound physique was the chief requirement. The men were cautioned not to enter the air on an empty stomach, to wear warm clothing on coming out, and to drink hot coffee.

The time worked in the air-chamber was limited to 8 hours with half an hour off for lunch, up to 32 lbs. gage pressure, and two spells of 3 hours each with 3 hours rest between for pressures from 32 to 42 lbs. and two spells of 2 hours each for pressures greater than 42 lbs. with 4 hours rest between, with no limitation as to decompression. Two medical air-locks were installed on each side of the river, well-warmed dressing rooms were provided for the workmen, and there were covered gangways for access to the shafts.

The air was cooled before delivery to the tunnels, and samples were taken in the tunnels by Mr. Noble's engineers and analyzed daily. The air was regulated so that the carbon dioxide did not exceed 10 parts in 10,000, and the tunnels were kept in a sanitary condition.

Owing to the grade of the tunnels being so deep on the Manhattan side of the river, the air pressure very quickly rose to 36 lbs.

Practically no cases of bends occurred until the pressure reached 29 lbs. and then, within a few days of each other, two men died. These men had entered the air-chamber without being passed by the doctor. Then it became necessary to post outside each air-chamber a guard whose duty it was to keep out of the tunnel men who had no doctor's pass. At this time, reliance could not be placed on the tunnel foremen, as they were likely to be absent from work, and new men had to be selected each day.

For many months after the work started, while the men were being seasoned, the tunnel gangs and foremen were in a state of change, owing to the difficulty of getting good men and the frequent absences due to caisson disease, and it was a long time before an efficient organization was built up.

As the tunnels were driven deeper beneath the East River the pressure quickly rose, and ultimately reached 36 lbs. gage pressure, with only one set of air-locks in operation; but even the change at 32 lbs. from one shift of 8 hours to two shifts of 3 hours each gave no relief, and cases of bends, sometimes fatal, continued all the time.

It was not long after 27 lbs. was reached that the more sensitive members of the staff found that it did not pay to come out quickly, and at 30 lbs. pressure it became a custom to take about ½ min. for each pound. After one or two additional fatal cases occurred, it was decided to limit the workmen to approximately the same rate of decompression, or actually 15 mins. for 35 lbs. pressure.

Many of the men complained that taking so long to decompress gave them caisson disease, and it was difficult to compel them to take long enough. The guards at the entrance to the tunnels had now to record the time taken to decompress, and, as the workmen frequently used the lower muck locks as well as the upper man lock, it was impossible to tell when the decompression commenced owing to the noise of exhausting air. Therefore it became necessary to run a small ¼-in. pipe from the exhaust pipe of each lock to the cabin in which the guard was stationed, a whistle was attached, and a small ball of cotton was suspended by a light string

over each pipe. The clerk, noting when the ball was puffed off for each lock, booked the workmen off as they left the lock. The material locks were fitted with inner material valves and, in addition, man valves of smaller size, and a pressure gage and a clock were fixed in each air-lock.

As the guard had already booked the men as they entered, he could tell if any were ex-

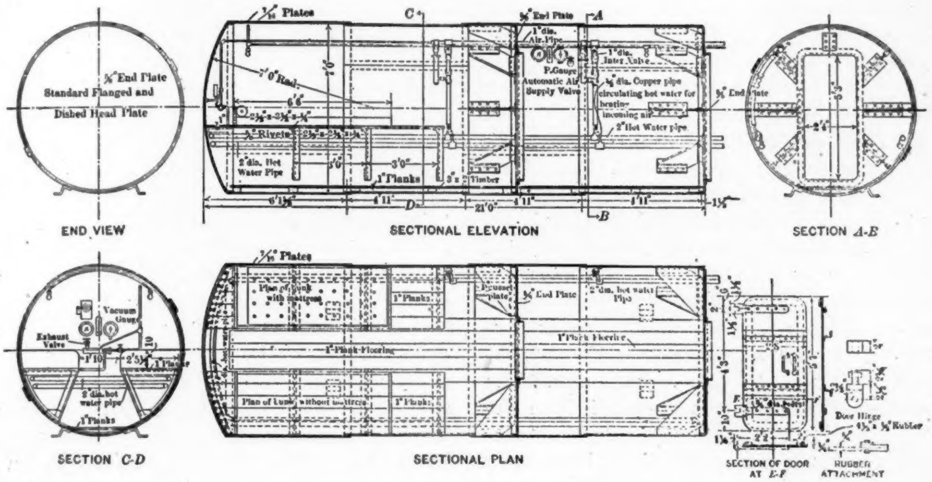


FIG. 2. MEDICAL AIR LOCK.

ceeding the regular working shift, and his record was valuable for checking the timekeepers. This rough method of checking the duration of the decompression was quite enough for the purpose. An attempt to improve it was made when a 12-in. Crosby recording gage was installed on one air-lock, but it was ineffectual because the air-lock was often sent out or decompressed with no one inside, and this complicated the record, which was much too small, and involved considerable trouble in locating the record of decompression for individual gangs. No doubt a suitable recording instrument could be devised for this special purpose.

The effect of lengthening the decompression period to 15 mins. reduced the number of cases of bends, and no doubt prevented many fatal ones, but they still occurred. As the tunnels had many months to run at high air pressures, the question was: What else can be done to prevent them?

The writer, on coming out of the tunnel
avoid this, a simple decompressing valve was

with the workmen, observed that the rate of decompressing was most irregular. One lock tender would allow the air to escape slowly until the 15 mins. was almost exhausted, and then, by opening the valve, would let off the remaining pressure very quickly. Others would reverse the process, and exhaust quickly, and then keep the men under 2 or 3 lbs. until the time expired. To

designed which gave a uniform decompression from 35 lbs. to atmosphere in 15 mins. A somewhat similar one was designed for the medical air-lock, for 1 hour decompression for 35 lbs. with an automatic ventilator attached.

These valves certainly improved conditions, but still fatal cases occurred. After the first valve was under operation, the writer's attention was called to "Modern Tunnel Practice," by D. McN. Stauffer, M. Am. Soc. C. E., wherein a description is given of a needle decompression valve used on the air-locks at the Kiel Dry Dock Works, in Germany. A similar valve was also used for compression. On entering the lock the air was admitted at the rate of 1.5 lbs. per min., and was decompressed at the rate of 3/4 lb. per min., or, for 35 lbs. gage pressure, 23 mins. for entering the air and 46 mins. for leaving. This needle-valve was often frozen up, but otherwise worked well.

Such speeds seemed altogether too slow, and Mr. Stauffer in his book states that

"these rates would be deemed excessively slow in American caisson practice." No date is given for the Kiel Dry Dock work, but presumably it was under way in 1904.

It was not thought advisable to increase the time of decompression at that time, but preliminary tests under air pressure in the tunnels for 1½ hours were then tried for green men, followed by a second medical examination after decompressing in 15 mins. A few men were eliminated by this test, and one case of permanent paralysis resulted from the test in 34 lbs. gage pressure. Fresh starters were made to stay in the tunnel for one-quarter of a shift for the first half, and if no caisson disease followed they were allowed to work for the second half. This proved a good safeguard.

On Nov. 8, 1906, a second bulkhead was put in operation in one of the tunnels, and the pressure between the two bulkheads was reduced to 15 lbs. gage. The number of cases of disease was very small for that tunnel, and as soon as possible additional bulkheads were placed in all four tunnels. The result was to have been expected from the experience in other tunnels where two bulkheads were used; the exercise of the long walk between bulkheads, at low pressure, seemed to assist in driving off the bubbles of air from the blood.

The workmen were allowed to decompress from 35 to 15 lbs. as quickly as they pleased. They then walked for 500 ft. along the tunnel under 15 lbs. taking at least 5 mins. and then decompressed from 15 lbs. to atmosphere in 10 mins. so that in all about 16 mins. were occupied in decompressing. When the inner pressure was less than 32 lbs. an 8-hour shift was worked, with ½-hour interval for lunch, between bulkheads in low air pressure.

Just when it looked as if the double bulkheads with stage decompression had eliminated fatal and severe cases of caisson disease, two deaths occurred in physically perfect subjects.

In order to discover, if possible, the connection between the cases of disease and other things, charts were plotted by the medical staff for some months, showing the rise and fall of air pressure, hours worked, humidity, temperature, percentage of carbon dioxide, and number of green men in the tunnel, along with barometer readings, condition of weather, direction of wind, and number of cases of bends. The results were not very encouraging, but it was noted that the number of green men, the height of pressure in the tunnel and the number of cases of bends varied together.

The percentage of cases in air pressure of 31½ lbs. for 8-hour shifts was no more than the percentage in 32½ lbs. for two 3-hour shifts—in fact, it was, if anything, less for the longer shift. The decrease in length of shift added one extra gang of men, and probably many of these men being green accounted for this.

In November, 1906, Mr. Moir became acquainted in part with Dr. Haldane's work of investigation for the British Admiralty on "Deep Sea Diving," and ordered the decompressing valves changed so that the decompression was accelerated at the commencement of the operation, and slowed off toward the end. In October, 1906, the writer, endeavoring to find out the effect of sudden decompression, fitted an ordinary glass siphon bottle with a valve and pressure gage. This bottle was partly filled with water, and put under 36 lbs. air pressure for 12 hours. On suddenly releasing the pressure, no effervescence whatever took place, and only a very few minute bubbles were visible. The same thing was tried with the bottle partly filled with bullock's blood, with like results. Arguing that the placid surface of blood in a stationary vessel offered no such opportunity for dissolving air as occurs in the lung surface with the blood circulating, the siphon was again charged with 36 lbs. pressure, but was rotated for 24 hours under this pressure. The same result as before was observed on suddenly releasing the pressure; but, on closing the valve, the pressure recorded on the gage was about 1 lb. per sq. in. in less than 1 hour, and in 6 days a pressure of 13 lbs. was recorded, showing that the air dissolved in the blood came off very slowly.

If the cork of a bottle of aerated water is drawn quickly, it effervesces so violently that the water froths out of the neck of the bottle; but, if the gas is allowed to escape slowly, only a mild bubbling results. This in general is the theory on which slow decompression has been advocated in the past. The violence of the escape of carbon dioxide gas from

aerated water, as compared with the escape of air from water released from pressure, is due to the greater solubility of carbon dioxide than air.

It was difficult to know what else could be done at this time in the way of eliminating caisson disease on the East River tunnels, and the cases of disease were certainly less frequent and less severe, although at long intervals fatal cases still occurred. The workmen, by this time, had become seasoned, and more seasoned men were now available from other works.

Dr. Leonard Hill read a paper on deep sea diving and caisson work, on Sept. 26, 1907, and exhibited the web of a living frog under a pressure of 20 atmospheres. On suddenly decompressing, bubbles were plainly visible in the blood vessels, multiplying quickly as they traveled along until the circulation was choked; on recompression the bubbles disappeared and circulation was resumed. He stated that he and Mr. Greenwood had been under an air pressure of 92 lbs. and had suffered no ill effects.

Dr. J. S. Haldane, on Nov. 29, 1907, read a most enlightening paper before the Society of Arts, in London, in which he gave the results of his investigation for the British Admiralty on "Deep Sea Diving." [See Compressed Air Mag., Dec., 1908. Page 5106, *et seq.*]

Dr. Haldane experimented with men and goats at high air pressures, with varying lengths of stay under air pressure, and with different speeds of decompression. From these he concluded that certain parts of the body, where the circulation is rapid and the number of blood vessels high for the mass of the part supplied, would be half saturated or desaturated in 5 mins., while other parts, with slight circulation for the mass, would require 75 mins. for 50 per cent. saturation, especially the fatty parts, as fat is found to dissolve about six times as much nitrogen as blood.

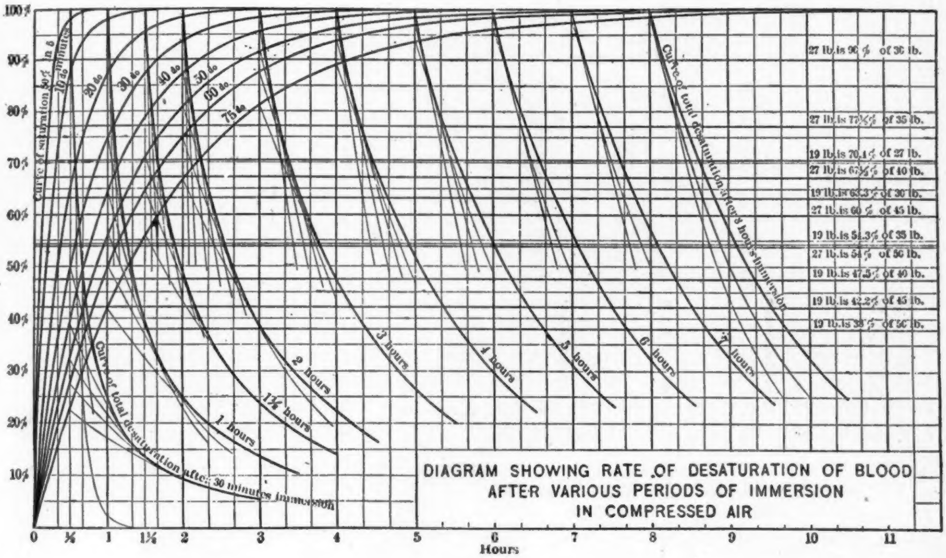


FIG. 3.

Figure 3 shows the rate of saturation, on the basis of half saturation in various times from 5 to 75 mins. and curves of desaturation, if the decompression is instantaneous after varying times of immersion from ½ hour up to 8 hours.

It will be seen that 90 per cent. saturation takes place in the slowest parts of the body in about 4 hours, and complete saturation for the quickest parts in about 40 mins., so that after 40 mins. immersion there is danger in too rapid decompression.

Dr. Haldane has noted that no serious cases of caisson disease have occurred for

rapid decompression at a working pressure of 19 lbs. gage pressure, or 2.3 atmospheres, absolute. Therefore, he concludes that it is always safe to decompress rapidly to half the absolute pressure, or even to the absolute pressure divided by 2.3, without bubbles being liberated. Further, if the decompression for the remaining pressure is continued at such a rate as will keep pace with the rate of desaturation, then, the absolute pressure of nitrogen in the blood never exceeding 2.3 times the absolute pressure in the air-lock during decompression or after returning to the atmosphere, no symptoms will occur.

**TABLE I.—Dr. Haldane's Rate of Decompression in Caisson and Tunnel Works.**

| Working pressure in pounds per sq. in. | Number of minutes for each period of decompression after the first rapid stage. After first 3 hours' exposure ........... | After second or third 3 hours' exposure, showing an interval for a meal......... | After 6 hours or more of continuous exposure .............. |
|---|---|---|---|
| 18-20 | 2 | 3 | 5 |
| 21-24 | 3 | 5 | 7 |
| 25-29 | 5 | 7 | 8 |
| 30-34 | 6 | 7 | 9 |
| 35-39 | 7 | 8 | 9 |
| 40-45 | 7 | 8 | 9 |

Table I shows the rates of decompression advocated by Mr. Haldane for caisson workers:

If the pressure is 40 lbs. gage, decompress rapidly from 40 lb. to $\frac{40 + 15}{2} = 27\frac{1}{2}$ lbs. absolute, or 12½ lbs. gage, in 3 mins. and then take 7 mins. for each remaining pound, viz., 12½ lbs. or 87½ mins. plus 3 mins. = 90½ mins. or 1½ hours in all for a 3-hour immersion; or, for a 6-hour immersion, 115 mins. in all. The upper diagram on Fig. 4 shows this graphically.

It will be seen that, if this rule is followed, the condition of the absolute pressure, being half the pressure in the blood, is obtained. If uniform decompression for the same time were adopted, the decompression would be too slow for the earlier part, would very much retard the desaturation, and would give a greater tension in the blood than 19 lbs. on coming out of the air pressure.

It is obvious that while the air-lock has any pressure in it the desaturation takes place only in relation to that pressure, and, if one adopts Dr. Haldane's idea of keeping a portion of the tunnel at half the absolute pressure for a dressing room to act as a purgatorial chamber, where the men may wash and change while desaturating down to 19 lbs. we must make a new curve for de-

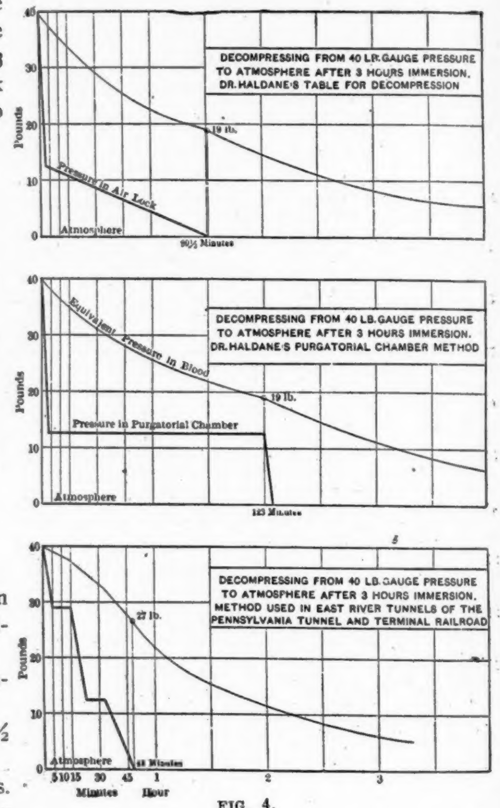


FIG. 4.

saturation and increase the time of decompressing, as will be seen by the second diagram on Fig. 4.

From this it appears that the tension in the blood does not reach 19 lbs. until a period of 123 mins. has been passed in the purgatorial chamber after 3 hours' immersion.

It will be noticed that Dr. Haldane bases his theory of decompression on the fact that no cases of caisson disease are chronicled for men working in gage pressures up to 19 lbs., or 34 lbs. absolute, and if it is safe to decompress suddenly from 34 lbs. absolute, to 15 lbs. absolute, it is safe to decompress

suddenly from 50 lbs. absolute, to 22 lbs. absolute, or from 35 lbs. gage pressure, to 7 lbs. gage pressure.

The question arises at once: Are the times suggested by Dr. Haldane practical?

Many caissons of small dimensions are sunk under air pressures of 35 lbs. and to cramp men in a small air-lock for 73 mins. is out of the question, and the fitting of large compartments in small vertical air-locks, as used in building foundations in New York City, would be difficult. In tunnel work it would be easier, but the present method of rapid decompression is so radically different from Dr. Haldane's suggestion that it quite appals one to think of taking so long.

The experience of most compressed-air works is that up to 27 lbs. gage pressure there is very little trouble, and using this as the safe limit the times required to reduce the saturation in the blood to 27 lbs. is not so excessive for pressures up to 50 lbs.

The horizontal lines on Fig. 3 show the equivalent points for 27 and 19 lbs. in the blood for 50, 45, 40, 35, 30, and 27 lbs. gage pressure.

It will be noticed that the slowly saturated parts of the body are only partly saturated in the first few hours of immersion, and therefore the desaturation is proportionately fast.

TABLE II.—Times (in minutes) required for pressure in blood to fall to the equivalent of 19 lbs. gage pressure with instant decompression after various periods of immersion in compressed air.

| No. of hours of immersion. | Gage Pressures. 27 lb. Minutes. | 30 lb. Minutes. | 35 lb. Minutes. | 40 lb. Minutes. | 45 lb. Minutes. | 50 lb. Minutes. |
|---|---|---|---|---|---|---|
| ½ hour.... | 4 | 5 | 8 | 10 | 14 | 16½ |
| 1 hour..... | 7 | 10 | 15 | 20 | 26 | 32 |
| 1½ hours.. | 10 | 16 | 24 | 32 | 40 | 48 |
| 2 hours.... | 14 | 21 | 32 | 42 | 52 | 62 |
| 3 hours.... | 22 | 30 | 45 | 59 | 72 | 82 |
| 4 hours.... | 28 | 39 | 56 | 69 | 82 | 93 |
| 5 hours.... | 33 | 44 | 60 | 74 | 86 | 98 |
| 6 hours.... | 35 | 47 | 63 | 76 | 89 | 100 |
| 7 hours.... | 37 | 48 | 64 | 78 | 90 | 102 |
| 8 hours.... | 38 | 50 | 66 | 79 | 92 | 103 |

(The times in Table 2, being for instant decompression, must be suitably extended for slow decompression.)

From Fig. 3, Tables II and III have been compiled; they show the risks taken in rapid decompression after long immersion.

If the decompression is slow, these curves will be flattened out, and a longer time will elapse before the saturation of the blood falls to the equivalent of 19 lbs. or 27 lbs., as the case may be.

TABLE III.—Times (in minutes) required for pressure in blood to fall to the equivalent of 27 lbs. gage pressure with instant decompression after various periods of immersion in compressed air.

| No. of hours of immersion. | Gage Pressure. 27 lb. Minutes. | 30 lb. Minutes. | 35 lb. Minutes. | 40 lb. Minutes. | 45 lb. Minutes. | 50 lb. Minutes. |
|---|---|---|---|---|---|---|
| ½ hour.... .. | 1 | 3 | 4 | 6 | 8 |  |
| 1 hour..... .. | 1½ | 5 | 8 | 12 | 16 |  |
| 1½ hours.. .. | 2 | 6 | 12 | 18 | 24 |  |
| 2 hours.... .. | 3 | 9 | 17 | 25 | 32 |  |
| 3 hours.... .. | 5 | 15 | 25 | 34 | 45 |  |
| 4 hours.... .. | 6 | 19 | 32 | 45 | 57 |  |
| 5 hours.... .. | 8 | 22 | 37 | 50 | 61 |  |
| 6 hours.... .. | 9 | 25 | 40 | 52 | 64 |  |
| 7 hours.... .. | 10 | 27 | 41 | 54 | 65 |  |
| 8 hours.... .. | 11 | 28 | 43 | 55 | 66 |  |

(The times in Table 3, being for instant decompression, must be suitably extended for slow decompression.)

Figure 5 shows the curves of decompression from 27, 30 and 32 lbs. gage, after 8 hours' immersion, and for 32, 35, 40, and 42 lbs. gage, after 3 hours' immersion, and 42, 45, and 50 lbs. gage, after 2 hours' immersion, on the basis that it is safe to decompress from 27 lbs. gage pressure, in 9 mins. This reduces the saturation in the blood to the equivalent of 25 lbs. on reaching atmospheric pressure.

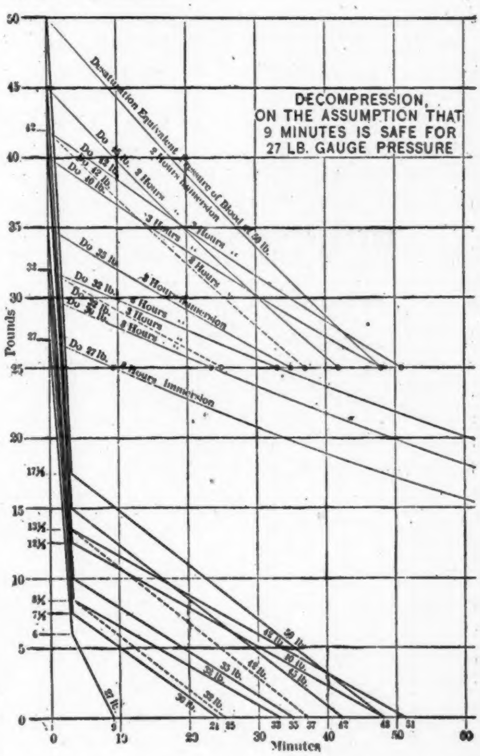


FIG. 5.

TABLE IV.—Decompression table based on 3 minutes being safe for 27 lbs. gage pressure.

| Gage pressure in lbs....... | Reduce pressure in 3 minutes to .......... | Total time in airlock after 8 hours' work.. | Total time in airlock after 3 hours' work.. | Total time in airlock after 2 hours' work.. |
|---|---|---|---|---|
| 27 | 6 lbs. | 9 | .. | .. |
| 30 | 7½ lbs. | 24 | .. | .. |
| 32 | 8½ lbs. | 33 | 25 | .. |
| 35 | 10 lbs. | .. | 35 | .. |
| 40 | 12½ lbs. | .. | 48 | .. |
| 42 | 13½ lbs. | .. | 51 | 37 |
| 45 | 15 lbs. | .. | .. | 42 |
| 50 | 17½ lbs. | .. | .. | 48 |

Table IV is taken from Fig. 5, and in part is confirmed by the experience in the East River tunnels as comparatively safe. Caisson disease will result, but no fatal or severe case should be experienced with physically sound men if these times are adhered to.

Some time after reading Dr. Haldane's paper and studying his theory, it became necessary to raise the pressure in the tunnels to 40 lbs. gage. It was possible to make the workmen pass through three sets of airlocks on leaving the tunnel. The inner chamber was kept at 40 lbs., the intermediate chamber at 29 lbs., and the outer chamber at 12½ lbs.

The men were ordered to take 5 mins. in the first lock, 8 mins. in the second lock, and 15 mins. in the third. There was a distance of approximately 1,000 ft. between each pair of locks. Walking this distance and gathering in the stragglers generally required 10 mins. to each chamber, so that, in all, 48 mins. were taken to decompress from 40 lbs. to atmosphere. No severe or fatal cases resulted, and little time was lost by the men through caisson disease, the cases being only slight. Under this pressure 330 men were employed for 36 days, working 3 hours on, 3 hours off and 3 hours on. It is true that no green men were used on this work, as there were plenty of experienced air men available at that time.

The third diagram on Fig. 4 shows the desaturation curve and rate of decompression, leaving the saturation of the blood equivalent to 27 lbs. on reaching atmospheric pressure. This result bears out in part the periods of decompression of Table IV, and, if a more rapid passage had been made through the first and second locks, probably a better result would have been attained, as the equivalent pressure of the blood would have reached 25 lbs. on coming out, as shown by Fig. 5 instead of 27 lbs.

In caissons or tunnels with but one lock, it is a difficult problem to allow workmen as long a time as Table IV indicates, as no one can enter the air-lock during decompression. One method of overcoming this difficulty would be to provide a lock with two small end chambers and a larger center chamber, four doors in all being necessary. Anyone making a short visit to the caisson could pass through without disturbing the pressure in the middle decompressing chamber. Fig. 6 is a diagram of such a lock with connections.

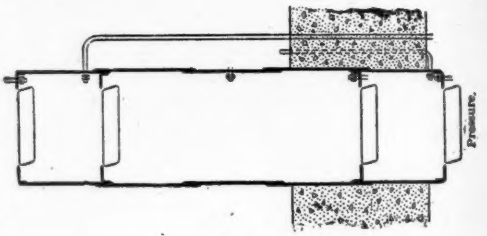


FIG. 6.

Some one has suggested, for diving bells and caissons, a detachable chamber like a boiler which the men could enter, and thus take as long as necessary to decompress.

The men on the East River tunnels rebelled against 15 mins. for decompression, but, after putting the responsibility up to the foremen, in time they found that it was a safeguard and voluntarily lengthened the time to 20 mins. and gladly submitted to 48 mins. for 40 lbs.

The death rate due to caisson disease was comparatively small, averaging 19-100 of 1 per cent. for the whole of the compressed-air work, and, from the experience gained, it would in all probability have been much higher if the decompression had not been lengthened.

The fact that the only recognized cure for caisson disease is recompression in a medical air-lock followed by slow decompression, is a powerful argument in favor of slow decompression, and where it is at all possible, in future works, regulated decompression will in all probability be adopted.

In caissons with small air-locks the volume

of air remaining when the lock is full of men is very slight, and very rapid decompression takes place. The workmen have a good opportunity to become seasoned in a caisson, as the pressure begins at 1 or 2 lbs. and gradually increases day by day as the caisson sinks, and the highest pressures are required for but a few days.

On the East River tunnels two caissons were sunk to a final pressure of 33½ lbs. and very few cases of caisson disease occurred, none of which were fatal although the decompression was rapid. On the other hand, on account of the tunnels on the Manhattan side starting out at a high pressure, the men had no chance to get seasoned, and many cases occurred, though the time of decompression was regulated, but not to such an extent as Table IV* indicates.

Thus far, practically, no grandfatherly legislation hampers engineers in the United States in compressed-air work, but such legislation is threatened, and engineers should be prepared to guide it. The engineer is confronted with conflicting testimony on all sides, and, though his experience shows that some men are capable of rapid decompression without injury, he also knows that many men are injured. Because a few men can for a time rashly take the risk, shall he eliminate good men from compressed-air work by putting them to such a test without endeavoring to make it safe for all who are physically sound?

## AN AMERICAN EXPOSITION AT BERLIN, 1910

An American Exposition is to be held in the Exposition Palace near the Zoological Garden in Berlin through the months of April, May and June, 1910. The exposition is intended to educate the European, and especially the German, population, to the importance and excellence of American manufactured products. The exhibits will be limited to articles of proven merit.

Everything will be provided for the exhibitor, so that when the exhibition price for space occupied is paid this will include all the items which usually figure as extras. Further particulars are obtainable from Max Vieweger, Manager, Hudson Terminal Buildings, 50 Church Street, New York.

## UNIQUE COAL MINING RECORD.

Eighteen years of coal mining, without a fatal accident from exploding gas or dust, is an excellent record for any mine. It is especially deserving of praise because the company achieving it is the largest coal producer in the world. Readers will find much that is unusual in the methods of preventing danger and accident, employed by the coal mining department of the United States Steel Corporation, as described in an article on the Gary, West Virginia Mines. Separate underground roads for the use of men only; prohibition of solid shooting; insistence on proper care of workings; scientific ventilation, and bonuses to officials for clean accident sheets, are a few of the causes which impelled the state mine inspector to report to Governor Dawson that these were the best mines he ever entered in his life. Such rules and conditions constitute a form of liability insurance which would be a profitable investment for any industrial corporation. Aside from the protection to human life, the effect of such an attitude upon the minds of employes is an incitement to better work and a deterrent to labor troubles.—*Mine and Quarry.*

## CHILDREN AND ELECTRIC WIRES

Mr. William Carroll, city electrician of Chicago, has sent a letter to the president of the Board of Education of that city directing attention to this important subject. Mr. Carroll thinks, and with good reason, that instruction on this subject should be given to the children of the public schools. There have been so many accidents caused to boys who come in contact with live electric wires by climbing poles on a "dare;" by picking up the loose ends of telephone wires that have come in contact with electric wires carrying dangerous potentials; by taking hold of broken electric-light wires; by throwing pieces of wire over trolley or other overhead wires to "see the sparks fly;" by using a piece of wire as a string with which to fly kites and having the wire come in contact with live electric wires, or by similar causes—that the danger is shown by experience to be a very real one, which must be guarded against. Mr. Carroll contends that the children should be taught to avoid wires of all kinds as they would rattlesnakes.

## FANS CIRCULATE BACTERIA

In Brussels an investigation has been made of the effect of ventilating fans in restaurants and other public places. Some of the ventilators simply agitated the air, while others were connected with openings in the wall. The experiments were made by determining the number of bacteria in a cubic meter of air before the ventilator had been started and after it had been running an hour or two hours. The results may be summarized as follows: In a number of cafés and restaurants the number of bacteria in a cubic meter of air, in the morning before the ventilators were started, ranged from 10,000 to 22,000. After an hour's running the number ranged from 17,000 to 48,000; after two hours' running the number ranged from 27,500 to 85,000. Another experiment was made in a laboratory where remedies for tuberculosis were prepared. Here the number of bacteria rose from 8,500 before the ventilator was started to 45,000 after one hour's running and to 75,000 after two hours' running. Another experiment was made in a private parlor. The number of bacteria per cubic meter, 650 before the starting of the ventilator, rose to 2,500 in one hour and to 4,000 in two hours. The ventilator was then stopped. Two hours later the number of bacteria per cubic meter had fallen to 700. These figures are so eloquent, that no further discussion is needed to show that the ventilators used in all these cases did far more harm than good, by creating a lively current of air which stirred up and carried with it dust containing bacteria.—*Scientific American.*

## DRILLS ADOPTED ACCORDING TO CONDITIONS

The selection of methods and tools for given purposes, in order to achieve the highest degree of operating economy, demands incessant study and an ability to accept the results of others' experience. In certain mining districts two-man rock drills of one or another size have come to be regarded as "standard," for all work. Miners in these districts have been surprised to find how much more economical a light, or "one-man" drill is for many purposes, and the innovation, which has been "standard" in other fields for years, is rapidly making converts. In like manner, drills larger than "standard" have been introduced in camps where hard times had closed many operations, with the result that mines have thereby reduced their costs of ground breaking and are running on ore too lean to show a profit under the usual system. Here is a practical subject for mining institutes and congresses to study.—*Mine and Quarry.*

## WHERE TO FIND THE MONEY

As to whom to approach in the search for financial backing, there can be no very definite advice. Usually there are a number of young men in every community whose parents are well to do, and who will advance a moderate amount of money to establish their sons in business. The names of such people can often be obtained from local bankers.

Business men, as a rule, have use for all the capital they can command, and are not likely to put money into stock companies that they do not control. On the other hand, professional men, like doctors, dentists, lawyers and architects, are much more apt to listen with favor to a proposition to invest in a stock company. Men of all classes who have come into money quickly, whether by inheritance, by speculation, or by a fortunate stroke of busniess, are nearly always ready to give ear to a business project that offers a greater return on their money than can be had from mortgages or bonds.

Engineers who try to secure financial backing for any project usually make the mistake of not studying the types of men to whom they wish to present it. They put in weeks, months, or possibly years, studying the engineering and commercial aspects of the problem. Then they go to some banker, to some professional promoter, or to some successful business man, and meet discouragement. The banker wants security, the promoter wants a "retainer" to start with. The successful business man wants more money for his own business. All want exactly what the engineer himself is in search of. Avoid people of these classes in financing a small business in which you seek to retain control; but go among salaried men, among professional men, among wealthy parents who have sons, and among people who have come suddenly into the possession of money. Among such people, a sound business proposition, if not on too large a scale, will always find the desired financial backing.—*Engineering-Contracting.*

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## AEROPLANE PROGRESS

It is absurd for any monthly publication to attempt the function of the *news*paper. News is made so rapidly, new things follow each other so closely, that even the dailies have to multiply their editions to keep up, and there is then a constant strife between the rivals for priority. It is as the historian rather than as the news purveyor that we mention the latest achievements in aviation at the moment of writing.

Louis Bleriot crossed the English channel with a small monoplane flyer on July 25, winning $5,000 offered by the London *Daily Mail.* The distance of 21 miles from the cliffs near Calais to Dover was covered in about 25 minutes, or at 50 miles per hour, with an average elevation of 250 feet.

Hubert Latham with a much larger machine made two attempts, once before and once after the above, descending the second time into the sea about two miles from Dover.

Orville Wright, on July 27, completed the official endurance test of the flyer which the Wright Brothers are under contract to furnish the U. S. Army Signal Corps. The test was for sustained flight with a passenger, and the drill grounds at Fort Myer, Va., were circled 77 times in 72 minutes at an average height of 50 feet, although as high as 125 feet was reached. On July 30 the contract requirements were all completed by a ten-mile cross-country flight with a passenger, and the Wright brothers will receive $30,000 for their machine.

No true historian can note the sequence of events without attempting to discover their connections and interdependencies, the invisible links in the so far completed chain of causes and effects, and no better opportunity could offer for the exercise of his function than in the mechanical successes of the age. When a thing is accomplished the achievement is apt to appear so simple that we all wonder why it was not done before, but later we find that one thing has been waiting for another all the way along, and that none have been able to go fast or far alone. This is most evident in the present status of the aviator. What it has waited for all along, what has prescribed its rate of development and achievement, what still holds it down is the motor. That in the course of events, and by the cooperation of the many, it will be

made more reliable and more capable of sustained and uninterrupted action none can doubt, and then we may not say how far and how safely mechanical flight may be carried. The up to date successes of the flying machine show us how those have helped it along who perhaps never thought of what would result.

## ROCK DRILL HISTORY—GENERAL HAUPT

A recent issue of *Mining and Scientific Press,* San Francisco, said that the first successful rock drill was designed by Sommeiller for the Mont Cenis tunnel and actually used in 1861. This elicited from a correspondent an interesting narrative enforcing the claim of Gen. Herman H. Haupt as the real pioneer in this field.

While yet a lad, he writes, I was fortunate in being thrown into close contact with General Haupt for a brief space, and the memory of the charm of his home life, the kindliness of his nature, and the rectitude of his spirit, remain with me vividly to this day. It was during this time that I first heard of his work at the Hoosac tunnel, and how the remarkable speed while the tunneling was under his direction had been accomplished by his invention and perfection of the rock-drill; and I recall being told that, after Governor Andrew had wrongfully succeeded in wresting the work from him, he was given a banquet by an engineering society in England as a recognition of his work in tunneling and in the invention of the rock-drill.

This is a boy's recollection of twenty years ago. Let us see if it can be verified. In "Reminiscences of General Herman Haupt," written by himself, appears on page 28, among "notes and a personal sketch by Frank A. Flower," the following: "At the time of the suspension of tunnel work in 1861, Mr. Haupt had made great progress in rock-drilling machinery, and had developed a machine that was far in advance of the perforator at work in the Mont Cenis tunnel at the same time. This drill was improved by a Mr. Taylor, in the employ of J. A. McKean, who represented Mr. Haupt in Europe and accomplished more rapid progress, at less expense for repair, than any drill used in the St. Gothard tunnel or elsewhere in the Old World; but Haupt never received any royalties or other compensation for its use. Mr. Haupt's knowledge of engineering principles, his great energy and experience, his genius for inventing more efficient rock-drilling and other machinery, and his tact and economy in the management of men . . . would have resulted in completing the tunnel without a cent of cost to the State;" and on the same page is the following: "For some years subsequent to the war, General Haupt followed his profession of consulting engineer in Pennsylvania. In 1867 he visited Europe, upon invitation of the Royal Polytechnic Society of Cornwall, to explain his system of mining and tunneling by power machinery. One of the rock-drills invented by him for use in the Hoosac tunnel, and which was the type of those used in driving through the great St. Gothard tunnel with so much rapidity, was on exhibition and received the highest honors awarded by the society."

The Hoosac tunnel was begun by Mr. Haupt in 1856, and his work there was continuous until 1862. My recollection is that Mr. Haupt perfected his drill one year after beginning work, which would make it in 1857, and give it priority of practical usage, and I believe the claim can be established that he also had priority of conception, although he never, to my knowledge, patented his device. It seems quite certain that, although the Mont Cenis tunnel was completed in 1870, and the St. Gothard not begun until 1872, it was the Haupt form of drill that was the most effective in the latter tunnel, and neither the Sommeiller nor the Mont Cenis form.

## WATER TRANSPORTATION IN EUROPE

"When I was in Berlin a few weeks ago, I met an American who was establishnig European agencies for the sale of a certain variety of glue, manufactured at Gloucester, Mass. In the course of our conversation he remarked that he could lay down his freight from Gloucester to Berlin for less than it costs to send it from Gloucester to Chicago.

"Now Berlin is rather more than 100 miles from the sea, but freight laid down on the docks at Hamburg is taken to the capital, through a veritable network of canals and canalized rivers, at a cost less than half what railroad transportation would involve. The

Elbe, the Rhine and the canals connecting and tributary to them are busy lanes of commerce, in sorry contradistinction to the deserted state of our canals and rivers. The ordinary type of boat is a barge of 200 to 250 tons burden sometimes propelled by a small engine, more often towed in strings by a tug.

"You will not see in France, Belgium or Germany deserted canals, waterways ruined by railroad encroachments, or such a pathetic spectacle as exists on several routes in the United States, railways running along the bank of a dry canal, all the locks on which have been blown up, lest it should be applied again to its proper function. No one of the three European states I have referred to could do its business without canals, and the business men of Berlin frankly admit that without artificial waterways the city would be a political capital and nothing more.

"To-day a cargo of cotton from Charleston, New Orleans, or Mobile goes straight to the docks at Manchester. But except in a limited area, and one continually decreased by railroad intrigue, our producers must use land carriage to get their cotton to the sea. If Manchester can profitably do so much for its manufacturers, cannot the United States do even more for the cotton planters of the South, or the wheat growers of the North?"—*Nashville Banner.*

## THE ELECTRIC AIR DRILL INDEPENDENT OF ALTITUDE

Two Electric Air drills have been put into successful operation at the Germania mine of Lizandro A. Proano, in the Huarochiri district of Peru. The elevation of the mine is nearly 16,000 feet, the absolute pressure of the atmosphere being only 8 pounds.

The rock at this mine is considered the hardest in Peru, and while progress with hand work was very slow it was considered hopeless to try to install machinery, the bad roads and the distance from a railroad forming additional discouragements. The drills were, however, determined on, at least as an experiment, the complete installation comprising a 45 kw. General Electric generator driven by a direct connected Pelton water wheel, and two Electric Air drills of the largest size, these each having a 5 h. p. motor.

The plant was put into operation as soon as possible after its arrival, Mr. Dick, of the commercial house of W. R. Grace & Co., taking charge of the work and also that of instructing the operators. They learned the complete management of the machines so rapidly that in a short time the drilling of the principal tunnel was under way, working with but one of the drills and advancing at the rate of a meter per day. As the progress which had been made by active hand work was only at the rate of 3 meters per month the advantage gained by the use of the drills was sufficiently evident.

This employment of the Electric Air drill emphasizes the fact that in its working it is entirely independent of altitude, or of the external air pressure, high or low. The air used is in a closed circuit, the high pressure which drives the drill piston in either direction and the very low pressure for the alternate movement being produced by the action of the pulsator pistons upon constant and unchanging—as to quantity—masses of air enclosed in the cylinder ends and in the connecting hose. The only compression of free air is that which is done automatically by the machine to compensate for the slight leakage losses. To operate regular air rock drills at this altitude the compressor would require to be nearly double the capacity of one at sea level for the same work.

## A WINDMILL SUGGESTION

Why is the full circle of a windmill of the modern type filled with blades? The only space not filled is the central eye and such small space as is represented by the angularity of the blades. The consequence of this may be that the wind deflected from the moving blade will be directed against the next following blade, and will hinder the rotation of the mill. With fewer blades the wind would pass away more freely, and it is likely that there would be more power generated per blade, if, indeed, not actually more power from a mill of a given diameter. The efficiency of the surface would probably be better. An ordinary windmill is simply an impulse turbine without guide blades. The wind advances in a parallel flowing stream and strikes upon the sloping surface of the sails or blades. These slip away under the lateral pressure of the air, and the air is deflected in the opposite direction, and can only get away between the blades. Such, at least, appears to be the trend of some recent thought on the question, and there is some reason in it. The old Dutch mills had only four, five or six sails,

as a rule. By no means was the full circle covered with sail area. Indeed, a mere fraction was occupied, and much greater sail area could probably have been added. The modern windmill is quite different, and has its whole circle occupied. Are there any tests on record to show what is the effect of this, and is it not quite likely that investigation would lead to changes in design?—*Cassiers.*

## DETAILS OF MINING PRACTICE

The aim of the miner is to take out ore at the lowest possible cost. In mining, the work of developing new territory and of exploiting the ore bodies already discovered is carried along at the same time. The work of prospecting is the main one at the beginning and at the end of the mine's life. It is necessary in the early days for the discovery of the ore bodies, and a property is not closed down until the work of exploration, which is done long in advance in a well-conducted mine, fails to expose new ore bodies.

The ore bodies are reached by a main thoroughfare, which is a shaft or a tunnel. Numerous side roads branch from it, and in their turn subdivide themselves often into smaller paths leading to rooms of various sizes.

In a flat country the thoroughfare is a shaft which may be straight or inclined but which goes down, and has for main utility to reach greater and greater depths. The side roads branching from it are the drifts or the tunnels run at regular depths, each usually one hundred feet deeper than the one above. As these side roads explore the vein on a given level they are called levels. These are the roads which lead to the rooms having no outgoing doors, such as the stopes. The stopes are the excavations in the ore.

The winzes, or small auxiliary shafts sunk from some level underground, and the raises, or chimneys raised from one level to another, are the short cuts between two levels.

The ore bodies lie in areas, which are cut as much as possible into blocks and squares and which are surrounded by the various roads and reached by them.

In good mining practice the ore bodies of one level are taken out, while in the one or two levels below these the blocks of ore are divided and the roads built for every day use. Again, in the two lowest levels new productive areas are discovered, the shape and the extent of the ore bodies are ascertained and the pathways that will permit the taking out of the ore in the cheapest and best way are planned and started. At the same time some roads may be driven into the country rock and fail to encounter the ore bodies which were hoped for along their course.

Each morning the men with their tools, powder and a supply of candles go down the shaft. A part of the men leave at each level—the first, the second, and so on—until the last one is reached. At each level the crew divides again, a part branching off to the left and the other to the right; and, again, along the drift the men separate to go to their different places in the stopes, till the mine is alive with men at work.

From all the extremities the ore comes down ore chutes to bins or storerooms above the drifts. From there it is dumped into small steel cars and the ore or waste rock, as the case may be, is trammed to the shaft and hoisted to the surface.

On the surface, if the car is full of waste rock coming from some barren portion of the vein or from some road driven through the country rock, it is piled on the waste dump. The car takes another switch if it is filled with ore and is dumped into large storerooms, called ore bins. The ore lies there till it is taken later on to some mill or smelter, where the metals are extracted:

When the mine is opened on the slope of a steep mountain it is much easier to use a main working tunnel instead of a shaft and branch roads, as crosscuts to the veins, drifts on the vein at the various levels, winzes and raises, are all connected with the lowest and main tunnel through which all ore taken out is finally trammed.

It seldom happens that the vein lies flat in the ground. In mines on veins dipping but slightly the main thoroughfare is a long tunnel, slightly inclined like the vein, which it follows, and called a slope. Each hundred feet roads are pushed to left and to right from the slope.

Some veins present near the surface a wide split up and the ore body can be taken out by a quarry or gigantic open cut.

The mine workings are cut in the solid rock by hard and patient work and at a great expense. In following the miner from the time he enters the mine it is easy to learn how he opens the roads through the solid rock with the use of dynamite, and to recognize what are the

different roads, shafts, tunnels, raises or winzes. When the ore has been reached it has to be removed. During the last fifty years great strides have been made in the art of mining which allow one to get the best results in nearly all the emergencies which may arise.—*Etienne Ritter in Mining Science.*

## A CANAL TO CONNECT THE BALTIC WITH THE BLACK SEA

A mixed syndicate of Russian and French financiers has approached the Russian government to obtain a concession for the construction of this great canal. The total cost of the work, plans for which were elaborated many years ago, has been estimated at $250,000,000.

The canal will begin at Riga and finish at Cherson, about 1600 miles, which could be traversed in 12 days as compared with 45 days for the Gibralter route. The minimum breadth of the canal is to be 140 feet and the depth 14 feet. From Riga to Beschenkowitch the course of the river Driva will be followed and the necessary work will consist of dredging and widening where required. From Beschenkowitch to Kopis-on-the-Dueiper, about 60 miles, will have to be cut out, and from Kopis to Cherson the Dusiper will be followed to its outlet on the Black Sea. This last stretch of 1200 miles will not present many difficulties for the engineers, but the overland portion will be very trying. Beschenkowitch is 378 feet above sea level and the ground rises steadily until the southern river is met. This will necessitate a great number of locks, and a subsidiary canal will have to be cut from Pripotz on the Gorin Sea to provide the requisite water. Quick construction is contemplated, so that if the work is begun within the present year it can be completed in 1914.

## SULPHUR DIOXIDE IN THE AIR

Writers in the past have paid but little attention to the presence of sulphur dioxide in the air. Various diseases of the air passages may be very materially influenced by the presence of this gas, and its effect on the general health of people is undeniable. It has been calculated that for every ton of coal burned in London something like three tons of carbon dioxide are produced, or about 90,000 tons per day. At the same time about 2,700 tons of sulphur dioxide are poured into the air. The effect of all this poisonous gas polluting the atmosphere cannot but be prejudicial to the general health of the community. To prevent such fouling of the air in all cities where there is a great consumption of coal, legislation should be enacted, making it a misdemeanor to throw out waste sulphurous gas into the air and a means should be devised to save the gas which is produced when coal is burned. Many useful applications of sulphur dioxide could be made which would more than cover the cost of its removal from the escaping furnace gases. —*Dr. Theodore W. Schaffer in the "Boston Medical and Surgical Journal."*

## ABANDONS "SIMPLIFIED" SPELLING

For two or three years "simplified" spelling has ruled more or less in the pages of *Profitable Advertising.* That journal and the *Selling Magazine* having now become one, under the title of *Advertising and Selling,* the following announcement is made:

The editor and publisher of P. A. had decided to return to Webster, and the simplified forms of the few words thus spelled would have been abandoned in the June number had there been no change in name or management.

The only argument against the recommendations of the Simplified Spelling board is the fact that the people do not like them. During the three years that P. A. spelled a few words in the simple manner, its course in that respect *was not once commended by one reader, and was constantly condemned by many readers.*

Inasmuch as it is an indisputable fact that our language has come to its present spelling estate through no other agency than the good pleasure of those who have spoken and written it, there seems to be no good reason for now attempting to deny to them that privilege. It seems also to be a fact that the simplifyers are trying to add to the broth an ingredient which they decline to allow to be incorporated. They carefully consider the scientific requirements of the formula, and prescribe the proper compound, only to discover that they are not able to induce a union—nothing better than a mixture—and that as soon as they quit stirring the mixture the new ingredients are precipitated, and the broth clears itself of them. So we rather regretfully abandon the simpler and more scientific and sensible forms of several words, and return to Webster, and the em-

phatically expressed predilections of our readers. The Simplified Spelling board endeavors to travel too fast in a direction in which the people do not wish to move at all.

### LIGHTNING FIRES A BLAST

A half acre of solid stone, twenty-two feet in thickness, was lifted by a single shot, and that shot was fired by a bolt of lightning at the Standard Lime and Stone Company quarries at Fond du Lac recently. Superintendent H. J. Murphy had just completed plans for a big shot. Eighteen deep holes had been drilled, in which 2200 pounds of dynamite had been placed and electric appliances attached. Noting an approaching storm, the superintendent gave the word to hurry, and before connecting up the battery to fire the shot took the precaution to run down the lead wires to avoid a chance of short circuits. Running one wire through either hand he started for the ledge where the charge was placed, when within ten feet there came a blinding flash followed by a terrific explosion, in which all the charges were fired and the half acre of stone hurled high in the air. Mr. Murphy's hands were severely burned by contact with the wire, but neither he nor his assistant was injured by the falling stone.

### NOTES

Heating a building with hot water from the jackets of a gas engine is to be tried at Detroit, in conjunction with a 1400-hp. engine and producer plant now being built for the Ford Motor Company.

The deepest producing oil well in the world is believed to be a well of the Los Alamos Oil Co. near Los Alamos, Cal., in the extension of the Santa Maria Field. It is 4,350 ft to the bottom and has yielded 600 barrels a day of 35 degrees gravity oil. The drilling of this well required two years.

The report of City Engineer Poetsch of Milwaukee gives the cost of a tunnel 7 ft. by 6½ ft. high, built last year under the Kinnickinnic river as $47 per linear foot. The tunnel, which was built to carry a water main under the river, is 295.3 ft. long, concrete lined, runs about 60 ft. below the surface of the river, the material penetrated being solid limestone. The cost of the shafts was $73 per linear foot.

The critical temperature of a substance is defined as being the temperature at which that substance will remain a gas, no matter what the pressure may be. According to Boyle's law, the volume of a gas is inversly as the pressure which it bears. Therefore, after passing the critical temperature a gas may be compressed to a greater density than if it were a solid.

The Sullivan Machinery Company has installed a branch office at Australasia Chambers, Martin Place, Sydney, New South Wales, to further the sale of its air compressors, rock and diamond drills, coal cutters, etc., in the Australasian commonwealths. Its establishment is due to the growing importance of the mining industry in that field. The new office is in charge of Mr. Geo. R. Mair.

A phenomenal jump in the world's tunneling record is reported. It will be remembered that in the Simplon tunnel 685 feet was driven in one heading in July, 1904. The north heading of the Loetschberg tunnel was advanced 990 feet in the month of June of this year. This heading is being driven in limestone, while the south heading is in crystalline schists crossed by dykes of porphyry, and here an advance of 545 feet was made for the same month.

A world's record for hand work tunnel driving comes from California, where in the Fernando tunnel of the Los Angeles aqueduct an advance of 579 feet for the entire tunnel section was made in the month of May. The ground is a soft sandstone with many nodulous boulders and frequent strata of hard altered sandstone. The volume of excavation is about 5 cu. yds. per lineal foot. From 14 to 17 holes are required per round. The men work in three shifts of 16 men each.

The Smithsonian Institute will erect on the very summit of Mount Whitney, Cal., (altitude 14,500 feet) an observatory which will enable investigators to study atmospheric conditions at great elevations, in dry

air, and in clear skies. The observatory will be erected from the Hodgkins fund, and will comprise a three-room structure of stone substantial enough to stand for centuries.

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Mixtures of air and aluminum powder are very liable to explosion. Recently, in a factory near Nuremberg, where a metallic surface is given to paper by the use of aluminum powder, the breaking of the globe of an inclosed arc lamp caused an explosion which killed two men and wounded several others.

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The headings of the Gunnison Tunnel on the Umcompahgre Valley Irrigation Project of the U. S. Reclamation Service met on July 6. Work on this tunnel was started some four years ago. The tunnel was driven from two points some six miles apart, one on the Gunnison River, where the water supply comes, and the other at Montrose in the Umcompahgre Valley. The tunnel is to have a concrete lining, the finished section being 10½x11½ ft.

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We "consume" much more than we actually eat or drink. For every man, woman and child of the ninety millions in the United States there is produced each week: Three-quarters of a pound of wire, more than three-quarters of a pound of rails, half a pound of structural shapes, three-quarters of a pound of plates, one-third of a pound of sheets, three-quarters of a square foot of tinplate, two and a half pounds of bars, hoops, etc., four pounds of iron castings. These and other finished iron and steel products make a total of twelve or thirteen pounds each week per head.

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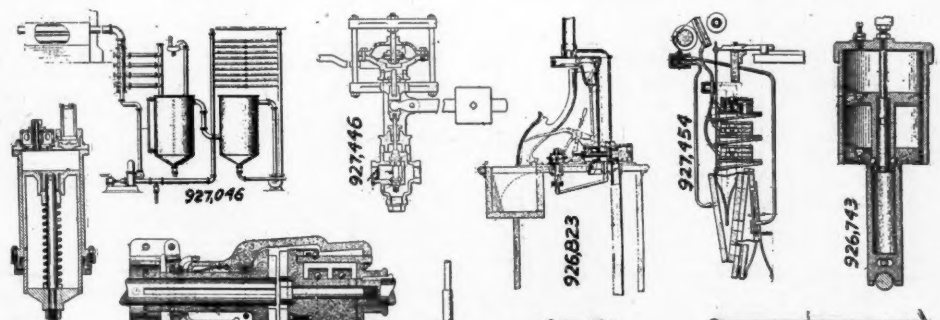
The Zeitschrift für Eis-und Kälte-Industrie says that the marine engineer, Dibois, breaks up river and sea ice by means of high temperatures. He divides the field into grooved squares, and deepens the grooves by means of a hydro-oxygen blast, produced on a sledge weighing 359 pounds, which lies outside, not over, the groove, so that the attendants do not risk a wetting if the ice should break unexpectedly. The sledge must be closely followed by workmen to remove the blocks of ice before the water in the grooves can freeze again, which can be delayed by the addition of a little salt.




PNEUMATIC PATENTS JULY 6.

## LATEST U. S. PATENTS

*Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, D. C.*

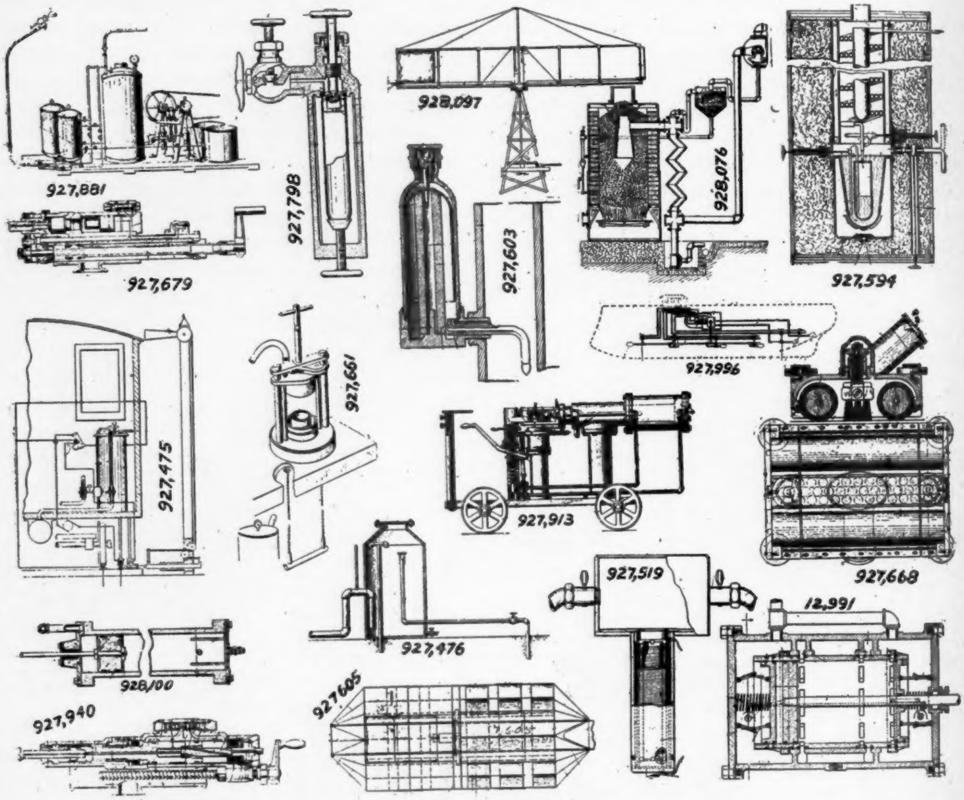
JULY 6.

926,743. RAILWAY-SIGNAL. JOHN S. HOBSON, Edgewood Park, Pa.
926,819. COMPRESSED-AIR ENGINE. BRUNO V. NORDBERG, Milwaukee, Wis.
926,823. PNEUMATIC-DESPATCH-TUBE APPARATUS. ALBERT W. PEARSALL, Lowell, Mass.
926,824. CARRIER FOR PNEUMATIC-DESPATCH-TUBE APPARATUS. ALBERT W. PEARSALL, Lowell, Mass.
926,971. MEANS FOR REDUCING AIR RESISTANCE ON VEHICLES. GEORGE A. AHRENS, Mukwonago, Wis.
927,229. PNEUMATIC CLUTCH. JAMES C. GARRETT, San Francisco, Cal.
927,434. AIR-HEATER FOR COMPRESSED-AIR ENGINES. HAROLD W. SHONNARD, East Orange, N. J., and WILLIAM DIETER, New York, N. Y.
927,444. STONE OR ROCK CHANNELING MACHINE. ALBERT BALL, Claremont, N. H.
927,446. VACUUM-GOVERNOR. GEORGE H. BEEBEE, Marshalltown, Iowa.
927,454. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. LEWIS B. DOMAN, Elbridge, N. Y.

JULY 13.

927,475. SAFETY APPARATUS FOR MOTOR-CARS. JOHN BARBERIE and THOMAS J. WALSH, Brooklyn, N. Y.

1. In a motor car provided with a motor, a feed conductor, a return conductor, an air reservoir and air brakes; devices arranged in an incomplete electrical circuit and in operative connection with said




PNEUMATIC PATENTS JULY 13.

reservoir, air brakes and motor and external means connected with a signal for completing said circuit.

926,972. METHOD OF AND APPARATUS FOR DRYING AIR. DAVID BAKER, Philadelphia, Pa.
927,016. AIR-BRAKE. ANDREW J. WISNER, Philadelphia, Pa.
927,046. METHOD OF TREATING ORES. HASCAL A. HOGEL, New York, N. Y.
927,081. GARMENT-PRESSING MACHINE. EDWARD SCHUMANN and ALBERT PREPEJCHAL, Chicago, Ill.
927,162. AIR-COMPRESSOR. THOMAS O. PERRY, Chicago, Ill.
927,181. ROCK-DRILL MAKING AND SHARPENING MACHINE. GRANT W. SMITH, Ottumwa, Iowa.
927,476. NATURAL-GAS SEPARATOR. ARTHUR W. BARKER, Fort Pierre, S. D.
927,519. OZONE - GENERATOR. THEODORE FRIEDLANDER, Chicago, Ill.
927,594. AIR-LIQUEFIER. JAMES F. PLACE, Glenridge, N. J.
927,595. APPARATUS FOR COOLING AND PRESERVING FOODS, ETC., BY LIQUID AIR. JAMES F. PLACE, Glenridge, N. J.
927,603. AIR-VALVE. FREDERICK H. SAUER, New York, N. Y.

927,605. AEROPLANE. JOHN SEILER, Union Hill, N. J.

927,661. PRESSURE CASTING APPARATUS. ROBERT N. LE CRON, St. Louis, Mo.

1. In a pressure casting apparatus, the combination with the receiver for the flask formed in separable sections movable one toward and from the other and the lower sections being provided with a bottom vent, of a flask having a perforated bottom and a peripheral flange around the perforated bottom adapted to seat in the lower section around the said vent, whereby air and gases may be forced from the receiver through the flask.

927,668. PNEUMATIC SWEEPER. ALBERT E. MOORHEAD, San Francisco, Cal.

12,991. VALVE MECHANISM FOR ENGINES AND COMPRESSORS. SIDNEY A. REEVE, New Haven, Conn. (Reissue).

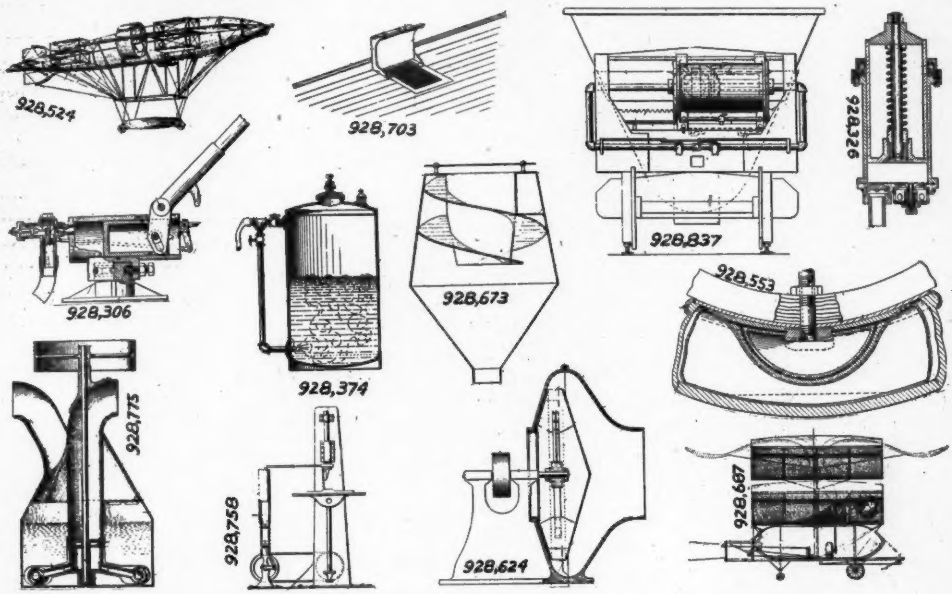
JULY 20.

928,296. PNEUMATIC ACTION FOR MUSICAL INSTRUMENTS. PETER WELIN, Newcastle, Ind.

928,306. TROLLEY - POLE - CONTROLLING MEANS. CHARLEY E. COZZENS, Toledo, Ohio.

928,324. APPARATUS FOR GENERATING HOT COMPRESSED GAS. HANS NEUMANN, Berg Gladbach, Germany.

928,326. AIR-COMPRESSOR. THOMAS O. PERRY, Chicago, Ill.




PNEUMATIC PATENTS JULY 20.

927,679. DRILLING-MACHINE. CHARLES B. RICHARDS, Cleveland, Ohio.

927,798. TRANSFERRING APPARATUS FOR FLUIDS UNDER HIGH PRESSURES. JOHN A. HOFF, Cincinnati, Ohio.

927,881. METHOD OF AND APPARATUS FOR ATOMIZING, ETC. ANTENOR SALA, Mexico, Mexico.

927,913. BOTTLE-BLOWING MACHINE. SAMUEL E. WINDER, Salem, N. J.

927,940. ROCK-DRILL. SANFORD W. BROTHERS, Denver, Colo.

927,996. SYSTEM FOR PROPELLING VESSELS. THOMAS MOTTON, Toronto, Ontario, Canada.

1. In a system for propelling vessels, a plurality of outlet ports through the hull below the water line, an air compressor suitably situated in said hull, conveying tubes or conduits communicating between said air compressor and said outlet ports, gate valves arranged in said conveying tubes or conduits adjacent to said outlet ports, a valve cylinder arranged in combination with said gate valve, means for operating said valve cylinder and gate valve, as and for the purposes specified.

928,076. APPARATUS FOR CONVERTING VOLATILE HYDROCARBONS INTO FIXED GAS. HARRY F. SMITH, Lexington, Ohio.

928,097. WINDMILL. JOSEPH BARKER, Carson City, Nev.

928,100. HOISTING-CYLINDER. MILFORD F. BERRY, North Bangor, N. Y.

928,181. VALVELESS PNEUMATIC TOOL. JOHN F. CLEMENT, Philadelphia, Pa.

928,334. PNEUMATIC TIRE. ROBERT J. RUTHS, Baltimore, Md.

928,357. PNEUMATIC MUSICAL INSTRUMENT. THEODORE P. BROWN, Worcester, Mass.

928,374. PAINTING-MACHINE. HIRAM E. FORD and FRANK E. TAYLOR, Detroit, Mich.

1. A pneumatic paint machine comprising a combined paint reservoir and pressure tank, an atomizer connected with the tank above the level of its contents to receive air under pressure therefrom, a paint suction pipe leading to said atomizer from the tank below the level of its contents, and means for introducing air under pressure to the tank below the level of the tank contents.

928,411. VALVE FOR PNEUMATIC TIRES. GRACE DE VIGNE, Cheltenham, England.

928,433. PNEUMATIC-TIRE ARMOR. CHARLES E. EVANS, Council Bluffs, Iowa.

928,524. AIR-SHIP. SIMON LAKE, Bridgeport, Conn.

928,553. SIGNAL FOR PNEUMATIC TIRES. SAMUEL SILVERMAN and JOSEPH E. TRAHAN, Watertown, N. Y.

928,624. PRESSURE-BLOWER. EDWIN BASSLER, Chicago, Ill.

928,673. CENTRIFUGAL APPARATUS FOR SEPARATING SOLID MATTERS FROM AIR. ANDRE LEBRASSEUR, Paris, France.

928,687. AEROPLANE AIR-SHIP. FRANK A. NEWELL, Terry, Mont.

928,703. HOT-AIR MOISTENER AND DEFLECTOR. WILLIAM M. ROEDER, Bloomington, Ill.

928,729. LIQUID GAS SUITABLE FOR ILLUM-

INATING AND HEATING PURPOSES AND METHOD OF MAKING SAID GAS. LINUS WOLF, Boston, Mass.

928,758. PNEUMATIC ATTACHMENT FOR MORTISING-MACHINES. ELMER E. HOUGHTON, Birmingham, Ala.

928,775. AIR-MOVER. AUGUST MATHIS, Chicago, Ill.

928,837. DUMPING-CAR. CARL P. ASTROM, Hasbrouck Heights, N. J.

928,867. TREATMENT OF ACETYLENE GAS. JOSEPH H. JAMES and HERBERT WATSON, Pittsburg, Pa.

1. The method of treating acetylene gas for storage, which consists in mixing together and compressing acetylene gas with the vapor of acetaldehyde, substantially as described.

JULY 27.

928,953. AIR-SEPARATOR. GEORGE S. EMERICK, Nazareth, Pa.

928,970. DUPLEX-PRESSURE EMERGENCY-BRAKE. THEODORE A. HEDENDAHL, Denver, Colo.

928,978. APPARATUS FOR REGENERATING VITIATED AIR. GEORGE F. JAUBERT, Paris, France.

929,033. FLUID-PRESSURE VALVE. JONATHAN M. SISSONS, Cranbrook, British Columbia, Canada.

929,055. PRESSURE-GOVERNING APPARATUS. WALTER V. TURNER, Edgewood, Pa.

929,066. PNEUMATIC CLEANING IMPLEMENT. DAVID T. WILLIAMS, Paterson, N. J.

929,092. HUMIDIFIER. JAMES KELLY, Providence, R. I.

929,111. FLUID-OPERATED TOOL. CHARLES B. RICHARDS, Cleveland, Ohio.

929,113. VACUUM MASSAGING - MACHINE. CHARLES B. RIDER, Ocean City, N. J.

929,150. MILK-CAN. GEORGE H. MARTING, Columbus, Ohio.

929,217. AEROPLANE. OSCAR HEEREN, Paris, France.

929,264. AUTOMATIC SPEED-REGULATOR FOR PNEUMATIC MOTORS. JOSEPH WIESER, St. Johnsvile, N. Y.

929,343. SPRAYING APPARATUS. FRANK SWEARINGIN, Batchtown, Ill.

929,351. PNEUMATIC TIRE. PAUL I. VIEL, Paris, France.

929,378. AIR-SHIP. CHARLES J. BERTHEL, Pinetown, N. C.

929,401. AIR-COMPRESSING PUMP. SVEN DAHLBERG, Springfield, Mass.

929,429. PNEUMATICALLY-OPERATED IGNITION DEVICE FOR GAS-ENGINES. CHARLES G. HESS, Center, Colo.

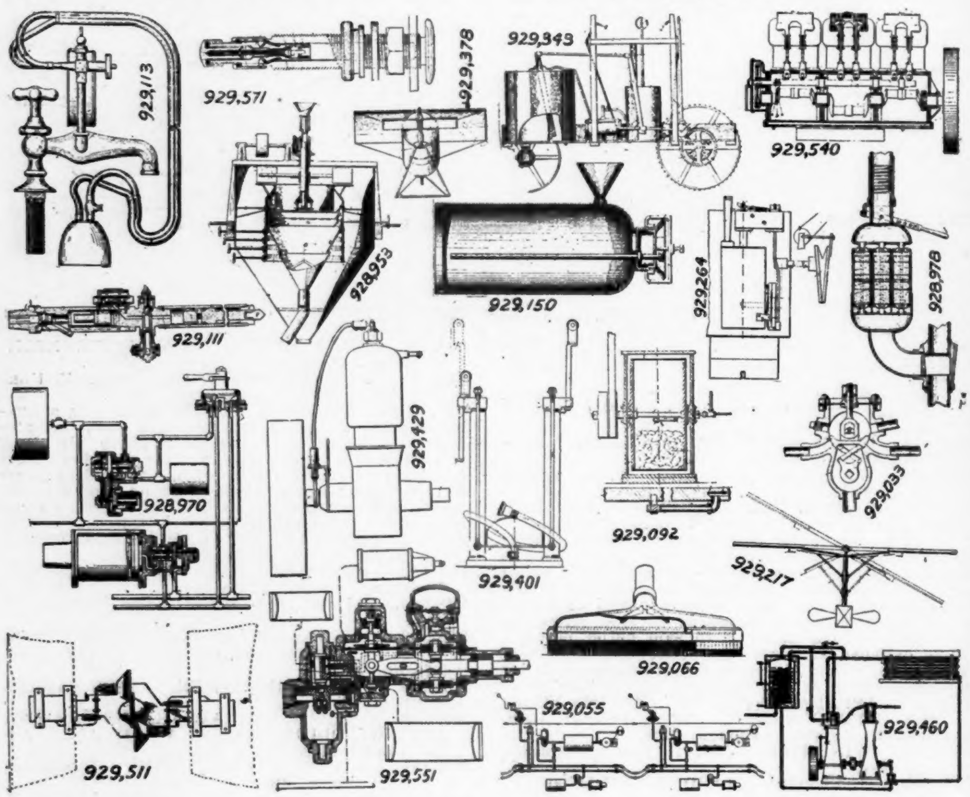
929,460. DEVICE FOR UTILIZING THE HEAT OF GASES DISCHARGED FROM COMPRESSORS. FRANK P. MORAN, Cincinnati, Ohio.

929,511. AUTOMATIC AIR-COUPLING. ALEXANDER E. SQUYARS, Laurinburg, N. C.

929,540. REVERSIBLE PETROLEUM AND COMPRESSED-AIR MOTOR. MARIUS BERLIET, Lyon, France.

929,551. ACCELERATOR FOR CONTINUOUS PNEUMATIC BRAKES. FRANCOIS J. CHAPSAL, and ALFRED L. E. SAILLOT, Colombes, France.

929,571. VALVE FOR PNEUMATIC TIRES. EDOUARD DUBIED, Couvet, Switzerland,




PNEUMATIC PATENTS JULY 27.